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MAY, 1964
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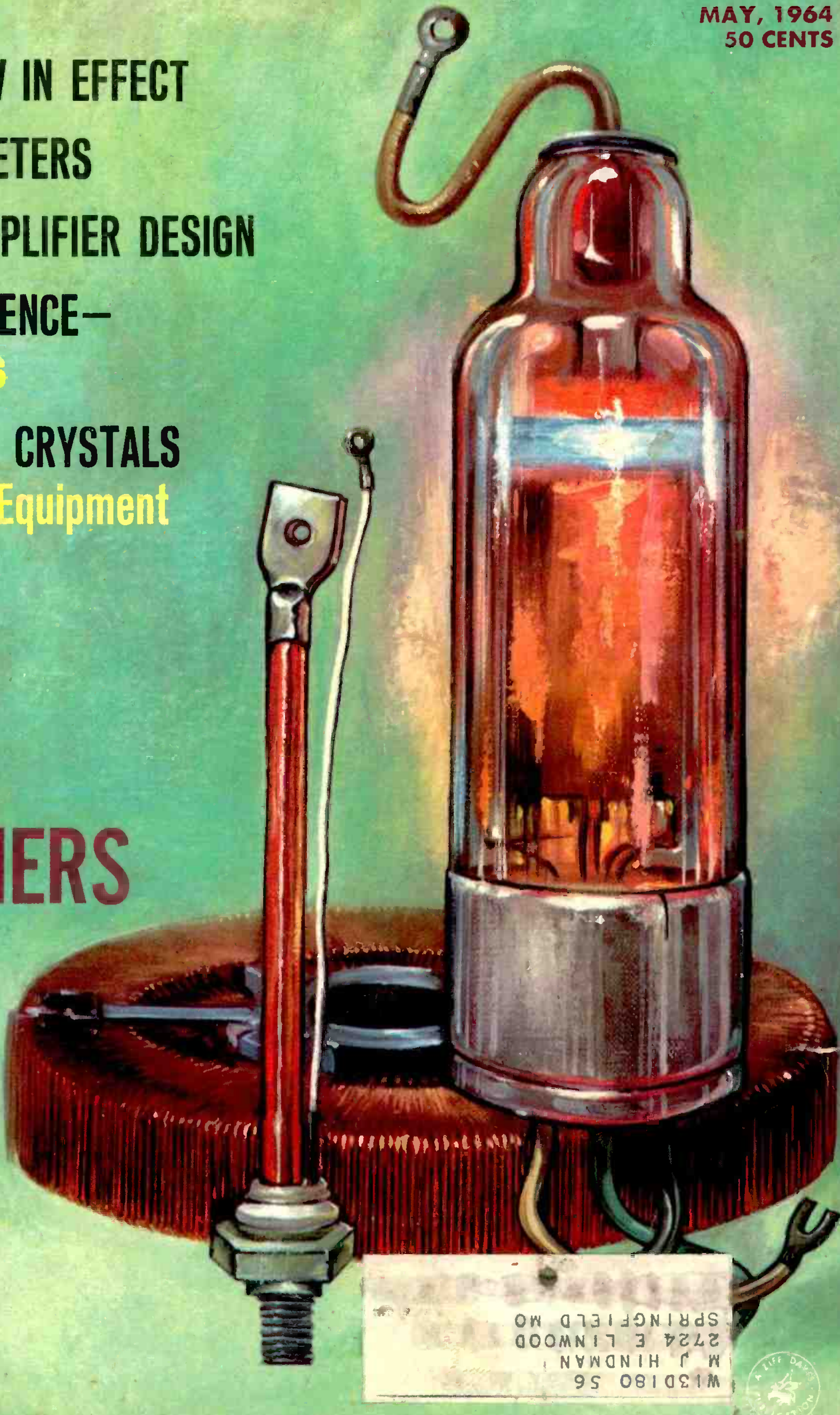

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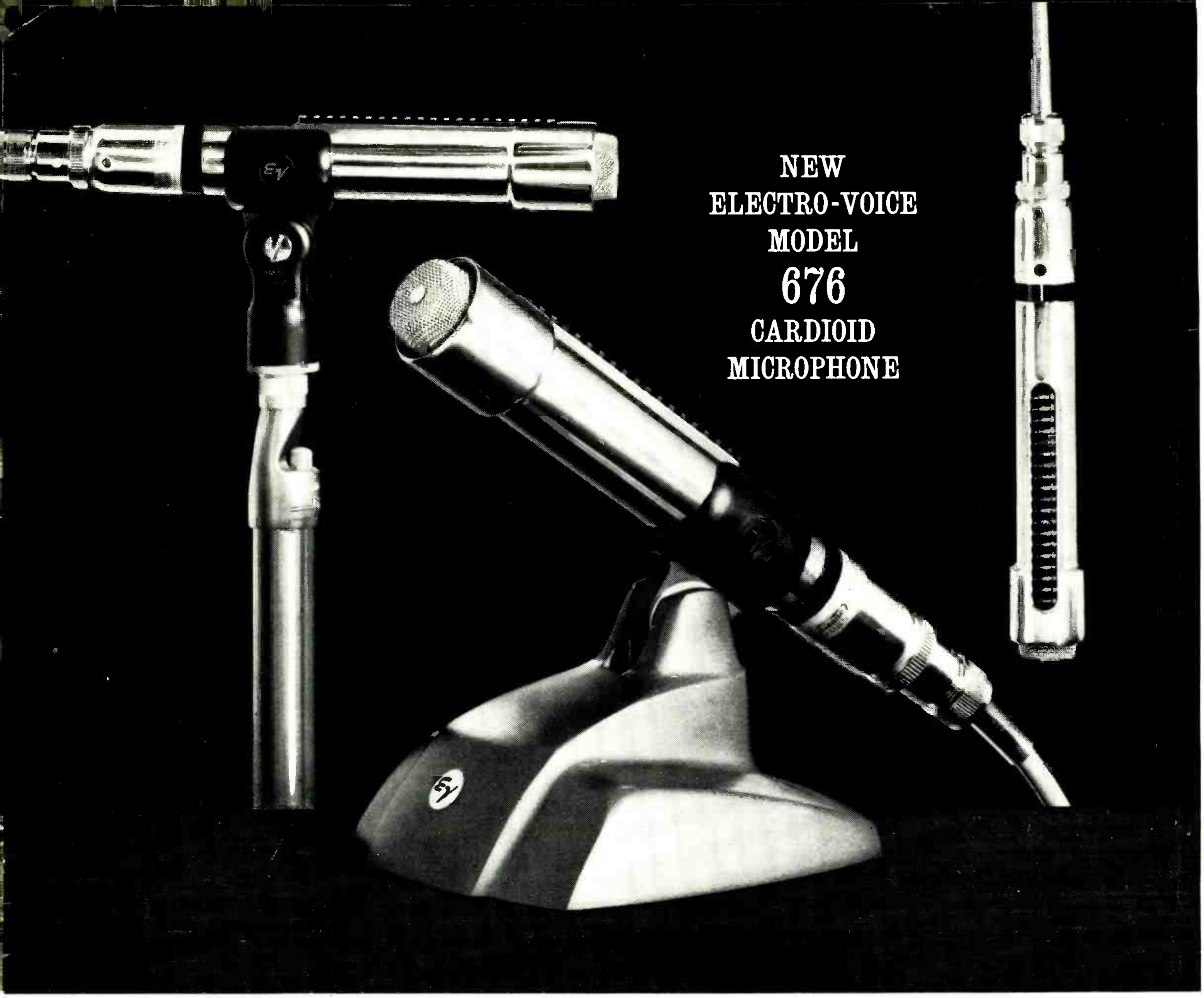

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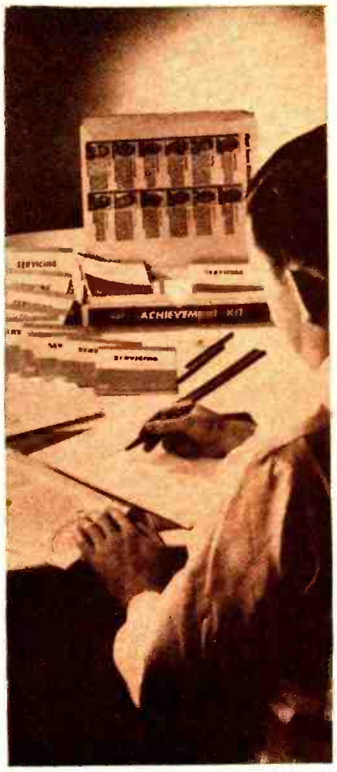

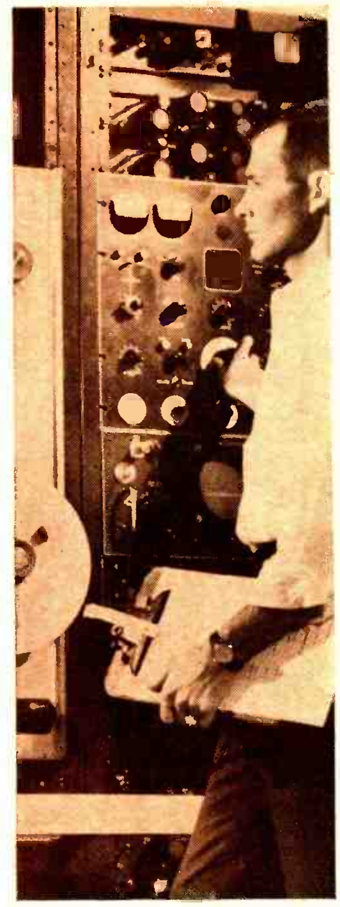

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Electronics World

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THIS MONTH'S COVER illustrates three devices that are commonly used to control and vary the intensity of incandescent lamps that are employed for lighting and display purposes. Other control devices include resistive controls, variable transformers, and, lately, solid-state switches. For a complete survey of the various techniques that are being used, their principles of operation, and comparative characteristics, refer to our lead article "Light Dimmers for Home and Industry." ....
(Illustration: Geo. Samerjan.)

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SIMPLE DWELL METER

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NEW U.H.F. TUNERS

Walter H. Buchsbaum takes a look at a number of the all-channel tuners being installed in 1964 TV sets. He analyzes tuners by Standard Kollsman, GI, Sarkes Tarzian, Oak, and Mallory.

DIODE CURVE-TRACER/ANALYZER

This simple instrument will check forward resistance, reverse resistance, and peak inverse voltage of semiconductor or vacuum-tube diodes, using a scope as the readout. An absolute minimum of parts is required.

PLUMBING THE MICROWAVE CIRCUIT

While conventional electronic circuits depend on point-to-point wiring to pass signals along, microwave circuits rely on interconnection by pipe-like conduit called plumbing. Author discusses its use in "wiring" and shaping microwave signals.

AMPLIFIER-GAIN NOMOGRAM

Handy chart for relating triode plate-load resistance to following grid resistor for various amounts of gain.

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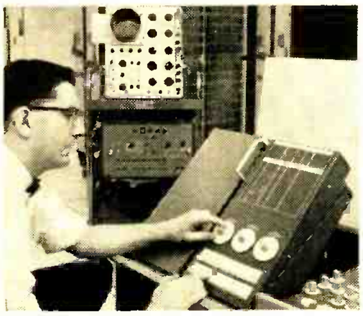

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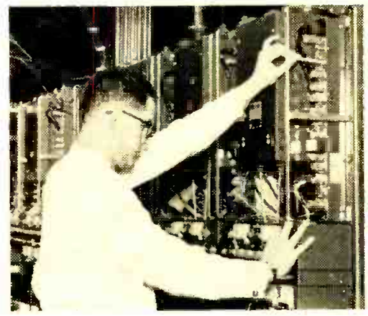

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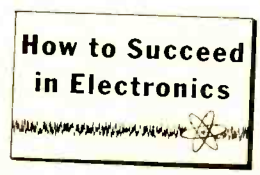

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For the record

WM. A. STOCKLIN, EDITOR

DEMAND FOR ENGINEERS AT NEW LOW

THE demand index for engineers and scientists registered 65.2 for December, 1963, as reported by *Deutsch & Shea, Inc.*, a New York manpower consultant firm. This figure marks the lowest point since the index was established in July, 1960, and reflects, in part, a continuing downturn in demand that persisted through 1963. The average monthly figure for 1963, they point out, is 97.7, which compares with 127.1 for 1962 and 100 for 1961.

Although the over-all economy was good in 1963 and shows strong evidence of continuing gains through 1964, engineers and scientists will find new jobs difficult to come by.

There are several factors operating to reduce the demand:

1. A plateau in the arms race has been reached and, as a result, our economically minded administration has decreed major cutbacks in defense spending.

2. A change in government procurement from a cost-plus policy to incentive-type contracts will eliminate "stockpiling" engineering talent.

Although the demand for engineers and scientists is at a new low, there is still a continued need for top caliber specialists. More with administrative background are also in demand. Manpower emphasis, according to the firm, will be on the applied level and away from the theoretical, and the key word in recruiting will be "quality."

The long-term outlook seems much brighter. There are many factors that point to an ever-increasing need for professionally trained, technically oriented people. The increasing complexity of products that are being created and planned will, without a doubt, require more technically oriented men. Just the maintenance alone on the equipment to produce these products will increase this need. Also, enormous investment in research over the past few years should lead the way to a vast number of new products, as yet unmarketed.

All of these points indicate that engineering opportunities will increase in the future. In fact, many industry spokesmen predict that starting in 1965 the demand will rise considerably. Yet, the incentive-type contract on which government procurement is now being based prevents accurate forecasting. The old cost-plus policy encouraged the stockpiling of engineers. It produced a psychological effect, in that companies showing the highest level of technical abilities had a better opportunity of getting contracts. This system would not affect profits, since contracts were on a cost-plus basis. Companies kept the extra engineers busy at drafting and miscellaneous chores that could have been handled by electronics technicians who, in many cases, would have been better qualified to do these jobs.

A recent study by the National Committee on Employment of Youth, a non-profit employment research group in New York, as quoted recently in *The Wall Street Journal*, estimates that only about half of the country's engineers are actually employed "in engineering work; the rest are acting in many capacities from draftsmen to salesmen."

With the change to the incentive approach, which should affect about 90% of all defense procurement by 1966, cost will be a most important factor. In an incentive-type approach, the manufacturer gets a bonus if the contract is concluded under the original estimate and; similarly, he will be penalized should the cost go above the estimate.

Assuming that there will not be any serious change in the cold-war status, it seems obvious that many engineers now functioning as technicians will be replaced. This will create an overabundance of engineers while, at the same time, tend to produce a shortage of highly qualified technicians.

It isn't so much a matter of dollars and cents in regard to salary. There is an overlap in salaries in that highly qualified two-year technical institute graduates can demand up to $500 per month in salary, while the less qualified or recently graduated engineer may, in many cases, only obtain $475 a month. It has been pointed out many times that a two-year college or technical institute graduate is trained to do many specialized tasks in an engineering department, while a four-year engineering college graduate lacks many of these abilities. It seems apparent, then, that the better qualified individual for a specific job will eventually cut costs in any operation.

It is difficult to predict the extent of this problem in the forthcoming years, but it would behoove any engineer today, who realizes that his function is not that of an engineer, to improve himself as quickly as possible through further education. Since the future holds great promise in specialized areas, it would seem obvious that further training in these areas would be the proper approach. ▲

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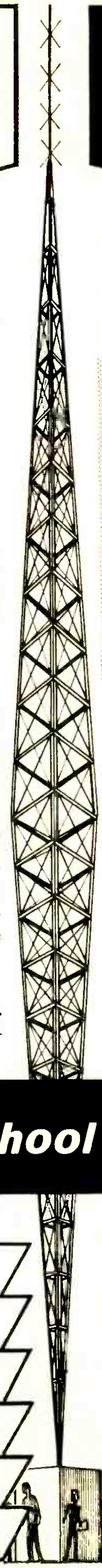

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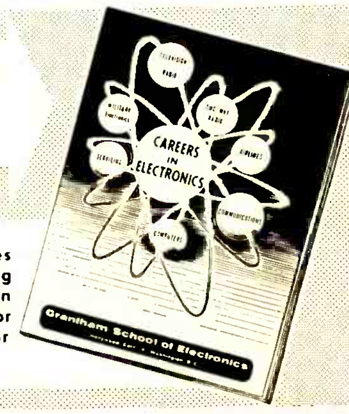

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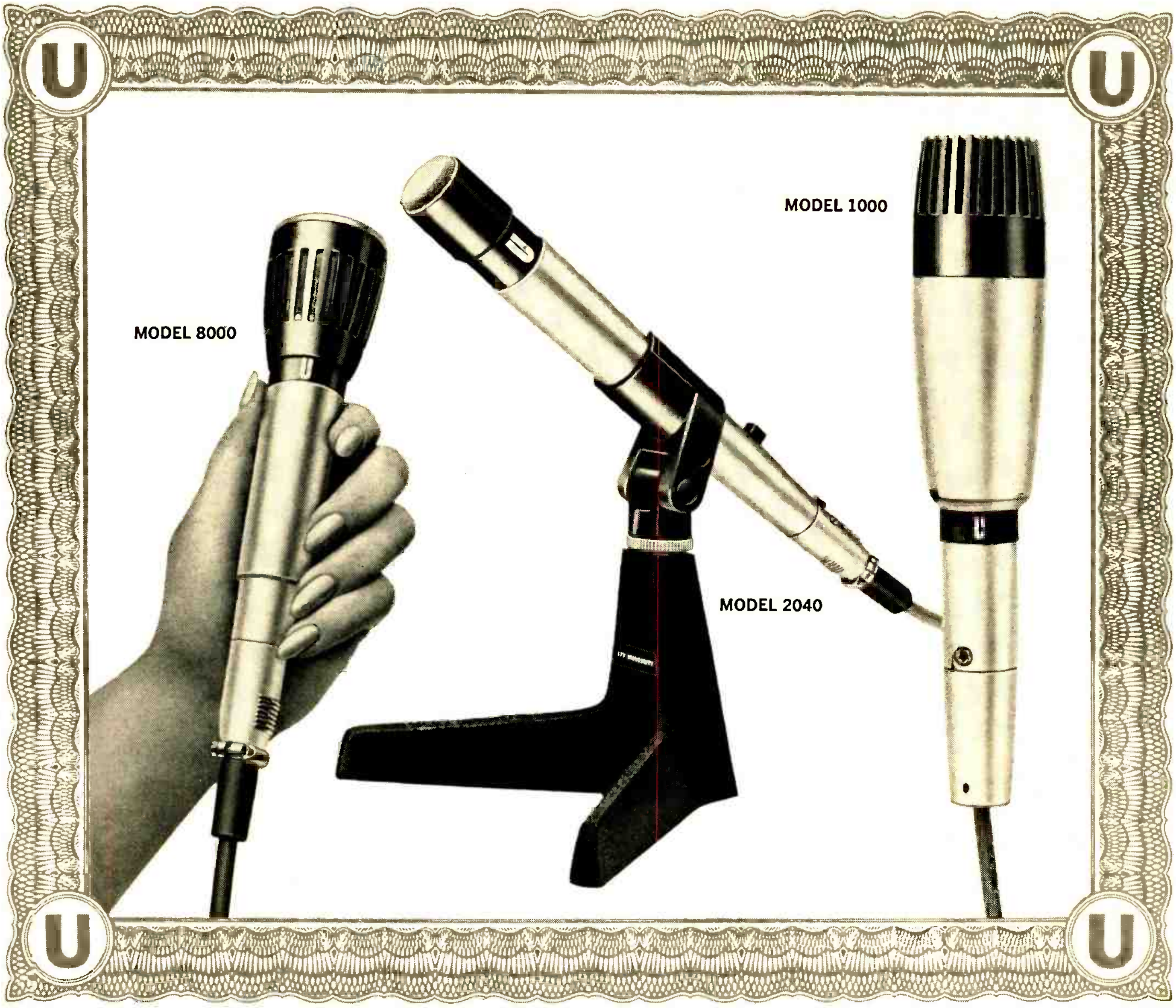

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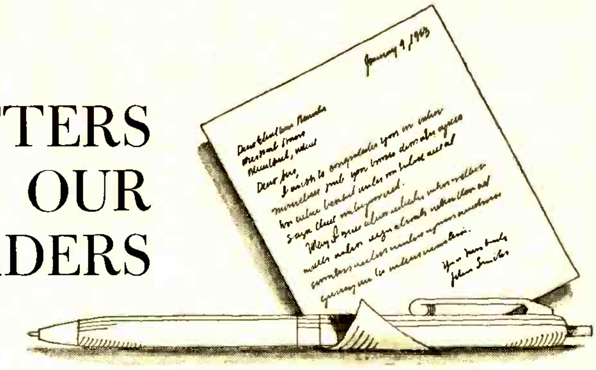
CIRCLE NO. 148 ON READER SERVICE PAGE

LETTERS FROM OUR READERS



HARRISON CHRONOMETER

To the Editors:

Captain T. S. Baskett's letter (ELECTRONICS WORLD, Jan. 1964) mentions that the first Harrison chronometer was on exhibit in this country and includes a photograph. I believe that the particular instrument shown is either Harrison chronometer No. 4 or No. 5. The first three made by him were of a different appearance entirely. Numbers 1 and 2 resemble a large mantle clock with counterweights protruding from the top corners. The earlier versions demonstrated the practicality of the design; the later models proved even better and were considerably more portable.

The accuracy of the Harrison chronometers and their progeny was not surpassed until the advent of quartz oscillators, at least for mobile application.

ALVIN F. RYMSHA, Engineer
Displays Design Section
Raytheon Co.
Wayland, Mass.

The photograph shown along with Captain Baskett's letter was actually of one of the later models, probably No. 5. —Editors.

* * *

TVI ON CHANNEL 2

To the Editors:

From correspondence in a recent issue (December) I note that high-pass filters are still being recommended as a cure for TVI on channel 2 from 6-meter ham transmitters. Although effective against transmitters which are not too nearby, I have found that even a four-section filter fails to suppress really strong transmission in the 6-meter band.

However, it is possible, using only a piece of 300-ohm ribbon lead-in, to make a shorted-stub trap which will completely suppress the interfering transmission without affecting channel-2 reception. The trap consists of a length of lead-in ribbon, one end of which is connected to the receiver input terminals, in parallel with the antenna lead-in, and the other end of which is shorted by skinning the two conductors and twisting them together. The exact length is important. For my interference, which occurred at 50.125-50.24 mc., depending upon which crystal my amateur friend was using, the optimum length was about 93".

The exact length required for complete suppression of the interference can be easily determined. A length of 96", or more, of 300-ohm ribbon is attached across the receiver terminals and the receiver is switched to channel 2. Then, when the interfering transmitter is on the air, the trap lead is temporarily shorted at different points near the end by gently squeezing through the insulation with a pair of diagonal cutters. (Be careful not to cut through the conductors while doing this.) When the correct shorting point has been found, cut the ribbon about ½" longer than this, skin each conductor, and twist the two ends together. The trap may be dropped behind the receiver.

L. W. REINKEN
Rectifier Engineering
Plainfield, N.J.

* * *

TO EXPERIMENT OR NOT

To the Editors:

It is a sad commentary on your editorial policy when I read answers to a reader's inquiry like that answer to Barry Whitmore's letter in the January 1964 issue of your magazine (*requesting construction details on lasers and electronic anesthesia—Eds.*) We cry for competent people to fill responsible positions in industry, particularly in the scientific fields and then a magazine of your caliber turns around and gives them half information, denying them their inquisitiveness as if they were small boys whose hands required slapping for reaching in the cookie jar because mom might have put a mousetrap there! Now how is a man to learn anything except by *going out and performing dangerous experiments with half information?*

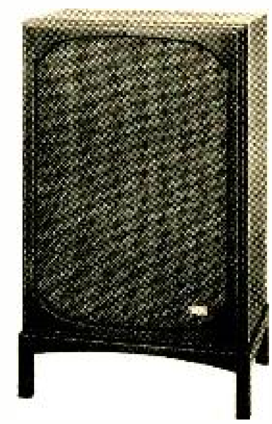
Certainly a laser is dangerous, but so is a car, a knife, crossing the street or any one of a million things we do every day as a matter of course. Also, there have been more deaths due to electrical shock than to laser burns.

Now, Mr. Whitmore can go out and get a good, high powered amplifier, feed it 700 cycles with a signal generator, put a transformer to give him the required voltage on the output and burn his brains out in the bargain. But wheth-

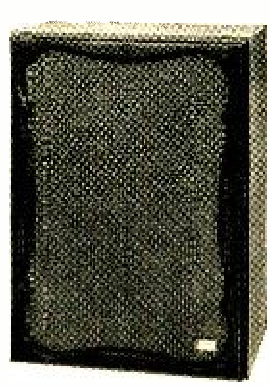
"A Medallion... 1

is a Medallion... 2

is a Medallion... 3



is a Medallion... 4



is a Medallion" 5

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5. *French Provincial*

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CIRCLE NO. 137 ON READER SERVICE PAGE

er you give him the fine points or not, he'll do the job if he's determined enough. So why not supply him with full and complete information including the hazards. At least he'll stand a chance then of avoiding the possible pitfalls.

BRICE WARD
Paramount, Calif.

We certainly agree with Reader Ward in principle, and of course we do not oppose experimentation since some of our articles are actually for the experimenter, whether he be technician or engineer. However, our reply to Reader Whitmore was simply an attempt to discourage the large amount of correspondence we get from students and from others who, from their letters, are obviously ill equipped to do such experimentation.

If an experiment is done with full knowledge of the dangers involved or under proper supervision, we are all for it. As a matter of fact, we recently went to a press meeting at which some high-school students had constructed a working laser. These students were aware of the danger involved as were their teachers and they acted accordingly.—Editors.

° ° °

TWIN-T OSCILLATORS

To the Editors:

Regarding Fig. 3 in my article on twin-T oscillators in the May, 1963 issue, the factor shown as f_m/f_o should read f_o/f_m to rectify the relationship as presented.

I have had inquiries concerning triggering of these circuits, and I am in the process of preparing another article on this aspect. The best triggering point is directly into the transistor base (through a capacitor) and the $R3/R1$ ratio should be just beyond the free oscillation point, *i.e.*, $R3/R1 \approx 40\%$.

To make this a practical system for control and provide good selectivity, it is necessary that the input signal be controlled within rather close limits.

FRED B. MAYNARD
Motorola Semiconductor Prod.
Phoenix, Ariz.

Author Maynard's article is scheduled for a forthcoming issue.—Editors.

° ° °

LINEARIZED BASE MODULATION

To the Editors:

I read with interest the article by Mr. William A. Rheinfelder on linearized base modulation ("Modulation Circuits for Solid-State CB Transmitters") in the February issue of ELECTRONICS WORLD.

Linearized modulation has been used by myself and others connected with amateur radio for a number of years with outstanding results. The system has been tried and proven on transmitters ranging from flea power to 1000 watts, on all amateur bands. The logs of the stations using it verify its effectiveness.

The writer's basic patent on this system is expected to be issued in the very near future and it is suggested that anyone interested in utilizing it should contact me.

JAMES W. BRYAN
828 Marilyn Rd.
Fairdale, Ky.

° ° °

DIGITAL VOLTMETER

To the Editors:

An error was made in a schematic used with my article, "Inside A Digital Voltmeter" in the November, 1963 issue.

Fig. 7 of this article shows a square-wave input into a three-stage amplifier with phase-inverted outputs. The output waveforms should be transposed.

SAM MESSIN
Non-Linear Systems, Inc.
Del Mar, Calif. ▲

Smashed sound in your symphony?

...then "bargain" recording tape's no bargain!

How does *cheap* recording tape get that way? It may be made cheap to sell cheap. Or it may become cheap because the maker goofed on quality, then sells the tape at cut-rate prices under unknown names. Dangers for audiophiles: Poor tape-to-head contact that causes losses or variations in frequency response. Background hiss. Squeal from poor tape lubrication. Or worse—abrasive wear to your recorder. In short, no bargain at all!

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Magnetic Products Division 3M COMPANY

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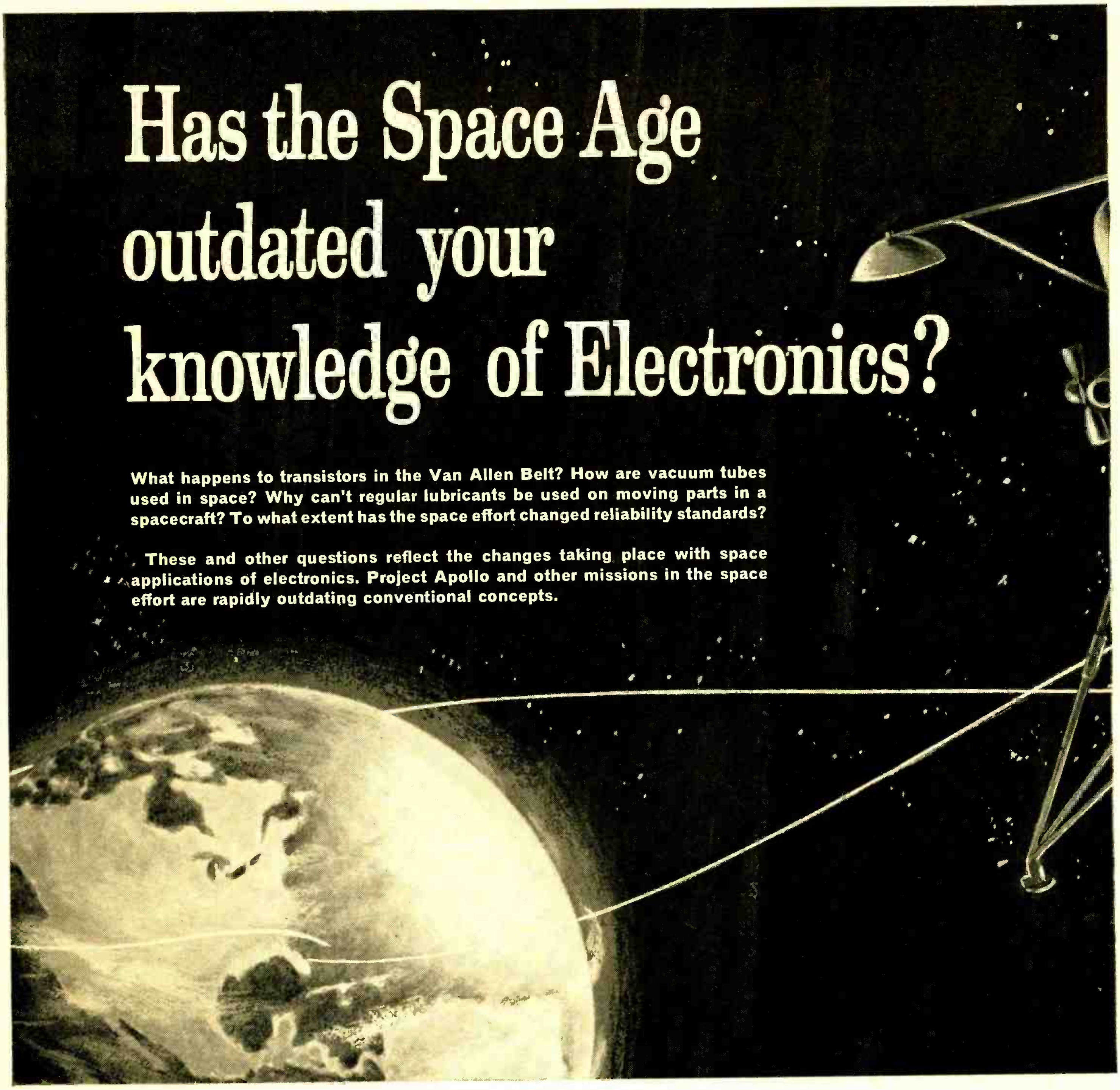

Has the Space Age outdated your knowledge of Electronics?

What happens to transistors in the Van Allen Belt? How are vacuum tubes used in space? Why can't regular lubricants be used on moving parts in a spacecraft? To what extent has the space effort changed reliability standards?

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For a career in space electronics you must acquire considerable new knowledge—knowledge that just didn't exist when you studied electronics. And, because developments in space electronics are quickly applied to other areas of electronics, knowledge of space electronics is an asset to a man in any field of electronics.

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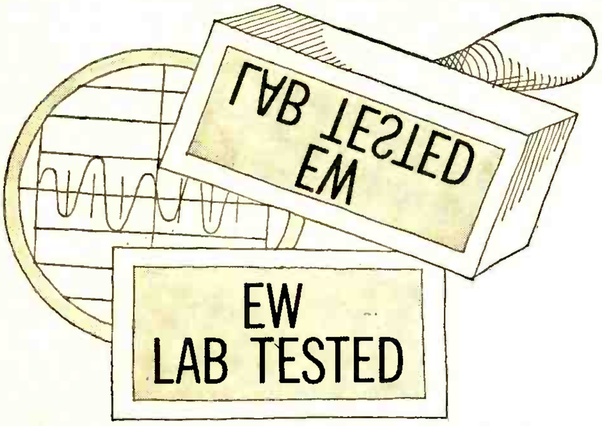
• The first extension programs developed specifically to help men in electronics apply their experience to the space effort.

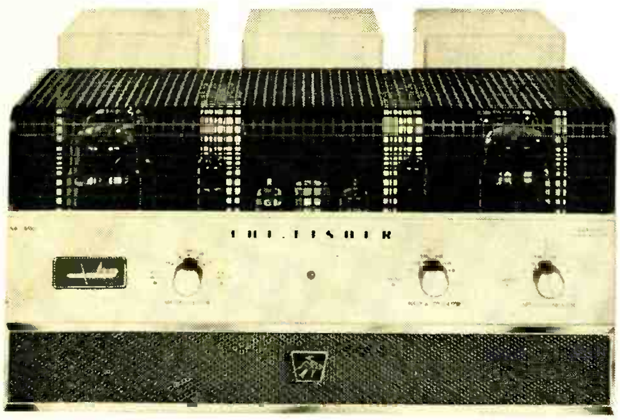


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS
Fisher SA-1000 Stereo Amplifier
Sonotone "Velocitone Mark IV" Cartridge

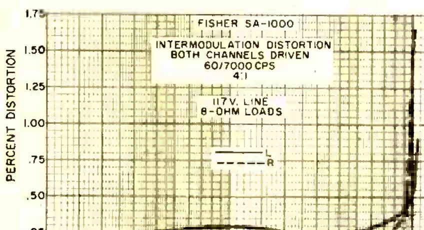
Fisher SA-1000 Stereo Amplifier

For copy of manufacturer's brochure, circle No. 42 on coupon (page 15).



THE *Fisher* SA-1000 150-watt stereo power amplifier is a true "heavyweight" of its type. Not only is it one of the most powerful single-chassis stereo amplifiers we have thus far tested, but its weight of 71 pounds places it at the top with respect to sheer mass.

Each input of the SA-1000 has a step attenuator, with calibrated settings of 0 db, 3 db, 6 db, 9 db, 12 db, and "Off." The high-impedance, continuous-level controls used on most amplifiers introduce a high-frequency loss as their settings are reduced from maximum. *Fisher*, reasoning that if a wide frequency response is desirable in an amplifier it should be maintained at any setting of its level controls, has employed capacitive compensation in the attenuator sections so that the amplifier's response is independent of their settings. A switchable subsonic filter in the input circuit rolls off the response below 16 cps to reduce subsonic noise or rumble which might be annoying or even damaging to the speakers.



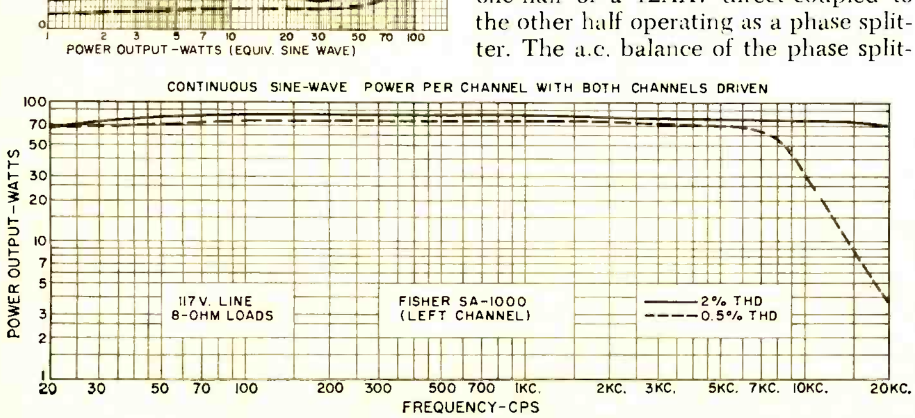
The attenuators are followed by the bootstrapped cathode followers with over 20 megohms input impedance. The cathode followers drive identical amplifier sections. Each amplifier begins with one-half of a 12AX7 direct-coupled to the other half operating as a phase splitter. The a.c. balance of the phase splitters is adjustable, but this requires distortion measuring instruments and is set at the factory.

A push-pull driver with a triode-connected 6HU8 has a 500-volt plate supply which allows very large undistorted voltage swings as its output. It drives the push-pull 8417 output tubes. These are husky tetrodes, operating with 620 volts on their plates and 420 volts on their screens. The massive output transformers have, in addition to separate plate windings, cathode windings which introduce 12 db of negative feedback within the output stage. There is 17 db of over-all negative feedback from the voice-coil outputs to the cathode of the first amplifier tube. Outputs are provided for 4-, 8-, and 16-ohm speakers.

The power supply has two separate voltage-doubling rectifiers, using silicon diodes, plus another silicon half-wave rectifier supplying fixed negative bias to the output tubes. A meter on the front of the amplifier may be switched to read the cathode current of each of the four output tubes. The bias for each tube is individually adjustable.

The published performance specifications on the SA-1000 are most impressive. Its IHF music power rating is 150 watts (both channels). The continuous power output at 1000 cps and 0.25% distortion is 130 watts. The intermodulation distortion, with test frequencies of 60 and 7000 cps in a 4:1 ratio, is 0.4% at 130 watts. The frequency response is rated at ±0.5 db from 20 to 20,000 cps, and the IHF power bandwidth is 11 to 50,000 cps. The sensitivity for full rated output is adjustable from 0.7 volt to 2.75 volts. Hum and noise are rated at 90 db below the maximum output of the amplifier.

Our lab measurements confirmed most of these figures—in fact, they are generally very conservative. With both channels driven, the combined output at mid-frequencies was over 150 watts with 0.5% distortion and 160 watts with 2% distortion. Even at 20 cps, where most amplifiers prove deficient, the SA-1000 puts out over 130 watts with 0.5% distortion and 137 watts with 2% distortion.



And beyond compare it is. There's simply no other way to describe the new Caravelle. It's unique in the stereo tape recorder field. Only the Caravelle has six heads. (Lets you record or play in both directions continuously without flipping reels.) Reverse-o-matic® plays any tape automatically to and fro for as long as you wish. Simple, too. Easy push button operation. Built-in echo control, sound on sound control, twin speakers, three motor system, center capstan drive. And there's more. In fact, we have a brochure crammed with facts. Send for it. You'll be amazed that the Incomparable Caravelle gives you so much for less than $399. For details and name of nearest dealer write to Concertone, Box 3866, South El Monte, California.

CONCERTONE

At 2% distortion, a full 133 watts could be developed at 20,000 cps. These measurements were all made with 8-ohm loads and it is possible that even lower distortion would be measured with 16-ohm loads. The IM distortion was under 0.3% at all power levels up to the rated 65 (r.m.s.) watts per channel. A combined output of 180 watts was measured at 0.4% IM distortion.

The hum was 73 db below 10 watts or 81 db below rated output with open input circuits. This is an inaudible level. The square-wave response was excellent, with a slight rounding of the leading edge of a 10,000-cps square wave and a 20% tilt on the top of a 60-cps square wave. The input attenuators, which were accurate within a few tenths of a db, had no effect on the shape of the 10,000-cps square-wave response, showing that the capacity compensation was doing its intended job well. The amplifier was stable under a variety of capacitive loads.

The frequency response at low levels was within ±0.75 db from 20 to 20,000 cps, which is very close to the rated response. The small difference may well be the result of instrument and measurement errors.

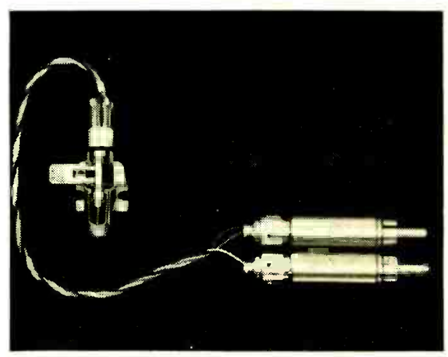
In listening to the amplifier, we were never able to use more than a fraction of its tremendous power reserves. It was, at all times, effortless and transparent and could undoubtedly drive the least efficient speakers under any conceivable home listening conditions without strain. One of the most noteworthy characteristics of the SA-1000 was its cool operation. Most amplifiers with over 100 watts capability on a single chassis run very warm, yet we operated the SA-1000 for hours on end, much of the time at full power output, without the transformers or chassis (except in the immediate vicinity of the tubes) becoming appreciably warm. Adequate ventilation is still important, of course, but the life of any electronic component is prolonged by operation in moderate ambient temperatures and we have not seen any other vacuum-tube amplifier which could match the SA-1000 in this respect.

The *Fisher* SA-1000 amplifier, complete with protective cage over the tubes, sells for $329.50. It is also available in kit form, for $279.50. ▲

Sonotone "Velocitone Mark IV" Cartridge

For copy of manufacturer's brochure, circle No. 43 on coupon (page 15).

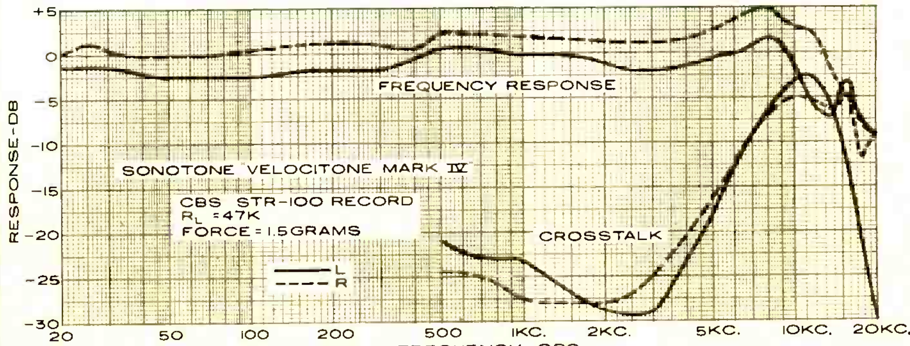
SONOTONE cartridges have, for years, surprised critical listeners who had always believed that ceramic cartridges were somehow inferior to magnetic types for high-fidelity applications. The 9TA series, introduced several years ago, provided sound quality which could not be distinguished from that of some of the best magnetic cartridges of the time, while retaining the inherent ruggedness, reliability, low cost, and freedom from hum pickup which characterize ceramic cartridges.

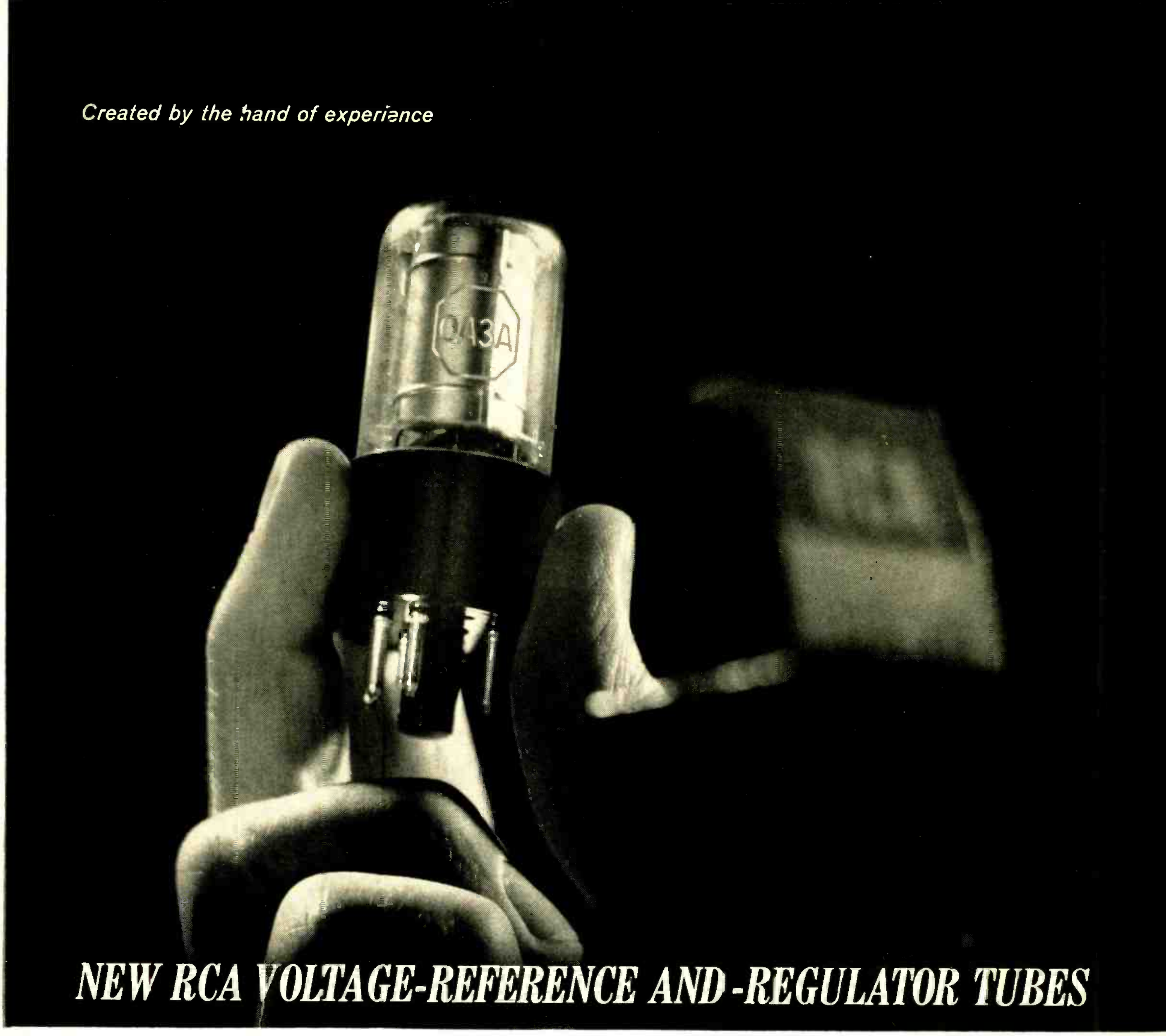


The 9TA cartridges (called "Velocitone" by their manufacturer) are supplied with a pair of plug-in equalizers which correct their inherent amplitude response to a velocity basis, at the same time reducing their output from a few tenths of a volt to several millivolts. Using the "Velocitone" equalizers, the *Sonotone* cartridges may be plugged into the magnetic phono input of any amplifier. If a high-impedance (1 megohm or greater) input is available, the cartridge may be connected directly to it without the equalizers. Its inherent response will provide an RIAA playback characteristic.

The "Velocitone" cartridges have undergone a series of refinements, which resulted in the "Mark II" and "Mark III" versions. The original model had a stylus

Response curve has been replotted below 500 cps using zero db as the reference.





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NEW RCA-OA3A, OC3A, and OD3A voltage-regulator tubes feature a smaller envelope for use in equipment where compactness is a major consideration. Yet these new types offer you the same long and dependable performance, and extreme reliability as their industry-proven prototypes: the OA3, OC3, and OD3.

Tube voltage drops (for dc-cathode-current range of 5 to 40 ma) are: 75 V (OA3A), 105 V (OC3A), 150 V (OD3A).

NEW RCA-5651A delivers the highest degree of voltage stability yet achieved in a miniature voltage-reference tube. Not only is voltage stability excellent initially, but remains so throughout tube life.

Maximum voltage drift throughout life of the new RCA-5651A is half that of the industry type OG3. Variation in initial tube drop from tube to tube is only 4 V maximum at any specific current value within the operating current range. And the RCA-5651A is essentially independent of ambient temperature in the range of minus 55°C to plus 90°C.

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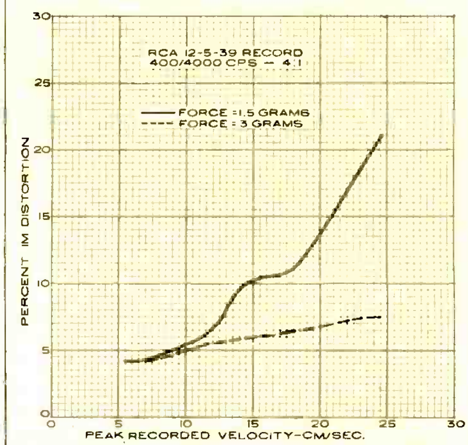

Note how IM falls as tracking pressure increases, but so does record wear increase slightly. Recorded velocities of 5 to 20 cm./sec. are common in present records. The test disc has residual IM of under 3%.

mass of 4.5 milligrams, a compliance of 3.5×10^{-6} cm./dyne, and a 2 to 5 gram tracking force requirement. The "Mark II" had a compliance of 5.1×10^{-6} cm./dyne, with a marked reduction in intermodulation distortion. Last year's "Mark III" unit had a stylus mass of 4 milligrams and a compliance of 6×10^{-6} cm./dyne. Its stylus arm was mounted in a flexible support which allowed it to be bent through alarming angles without damage. This makes it nearly indestructible in normal use.

The latest version, the "Mark IV," brings its specifications into line with the current state of the art in cartridges. For example, its stylus mass of 3 milligrams and compliance of 15×10^{-6} cm./dyne compare favorably with most good magnetic cartridges and permit the unit to track at 1.5 grams in good arms or up to 4 grams in record changers. The cartridge output has been reduced somewhat, but is still in the millivolt range, which is typical of present-day magnetic cartridges. Without the equalizers it is 0.2 volt, still sufficient to drive the high-impedance inputs of most amplifiers.

Our frequency response and crosstalk measurements on the "Mark IV," using the *CBS* STR-100 test record, were nearly identical to those made on its predecessors. Over-all it is flat within ±2 db from 20 to about 10,000 cps, with some irregularity at higher frequencies. The channel separation is 25 to 30 db at middle frequencies, reducing to an average of 5 db at 10 kc.

The effect of the increased compliance is immediately apparent in the tracking force requirements. Velocities as high as 30 cm./sec. at 1000 cps (the *Fairchild* 101 test record), were tracked at only 0.75 gram with low distortion, a feat matched by few, if any, cartridges we have tested in the past. The high-amplitude, low-frequency bands of the *Cook* Series 60 record required 3 grams

(*Continued on page* 58)

New 345 Tuner/Amplifier... the engineering leadership you expect from Scott at an unexpected low price

The 345 is an exceptional accomplishment . . . even for Scott. It combines the features, the performance, the specifications of separate tuners and amplifiers and sells for less than $350. Achieving this rare combination of top performance and top value took many long months of painstaking research and around-the-clock work from the most imaginative engineering minds in high fidelity . . . the Scott Advanced Development Group.

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1. Low Impedance Symmetrical Drive — an all new amplifier circuit that provides more power (65 watts of clean music power), lower distortion, cooler operation, and complete stability.

2. Series-Gate Time-Switching Multiplex provides probably the greatest stereo separation of any combined tuner-amplifier available. The 345 offers the ultimate in startlingly live stereo sound.

3. Pulse Suppression-Limiting effectively offers four stages of limiting for improved suppression of impulses from sources like automobile ignitions. 2.2 uv sensitivity for quiet noise-free FM sound.

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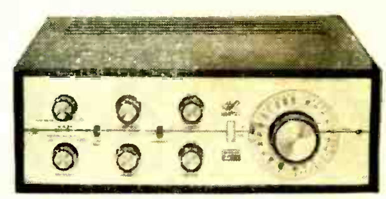
Eico 430 General Purpose 3" Scope. Flat-face CRT with mu-metal shield. Kit $69.95; wired $99.95

New Color and B&W/FM Sweep Generator

Eico 369 TV/FM Sweep generator, with built-in post injection marker adder. Kit $89.95; wired $139.95

New  CB Transceiver

Eico 777 dual conversion 6 crystal-controlled channels, 5-watts. 3-way power supply. Kit $119.95; wired $189.95



New Stereo Rcvrs.

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New Stereo Tuner Eico Classic 2200 FM-MX Stereo Tuner. Kit $92.50; wired $119.95 (Incl. F.E.T.)

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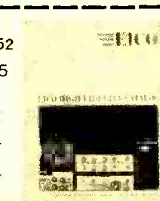


CIRCLE NO. 112 ON READER SERVICE PAGE

LIGHT DIMMERS for HOME and INDUSTRY

By FRED M. WOLFF
Vice-President, Engineering & Production
Century Lighting, Inc.

Intensity controls for incandescent lamps have now advanced from early resistive types to solid-state electronic controls using SCR's and solid-state switches. Here is an over-all survey of the various techniques that are now in use, their principles of operation, and their comparative characteristics.

FOR many decades the control of artificial light, other than by switching circuits "on" or "off" or varying the size of lamps, was limited almost entirely to applications in the theater. If television studios and concert halls are included in this general category, this is still true. But since World War II, the "theater" has invaded business offices, stores, and homes. The sale of merchandise is not too different from the "selling" of an idea in the theater. And why should dramatic effects be limited to the legitimate stage?

Light possesses four characteristics: intensity or brightness, color, form or distribution, and movement. Any or all of these characteristics may be altered by changes in intensity of one or more light sources. Color may be changed by varying the relative intensities of two differently colored lamps. Distribution may be varied by increasing "downlighting" as compared to indirect or "cove" light. Movement is merely the process of changing any of the others.

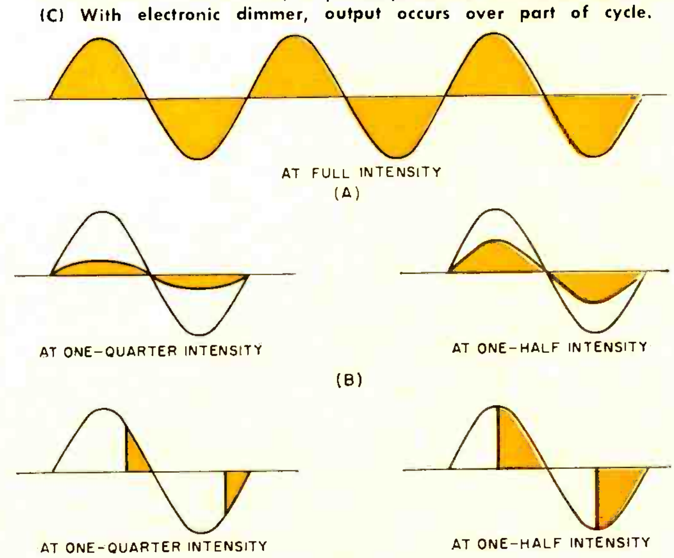
When the characteristics of light and its potentials are realized, the problem becomes one of control—primarily control of intensity—and this means control of voltage and/or current. Disregarding, for the moment, direct current which is now relatively rare as a source of power, alternating current can be controlled in one of two ways: either (a) the amplitude of the impressed a.c. wave may be increased or decreased, or (b) the period of the generating cycle's connection may be varied. All control circuits of whatever type utilize one method or the other. See Fig. 1.

In the theater, various types of control equipment have been refined and extended to achieve maximum sensitivity and delicacy of operation. "Mastering," "presetting," "fading"; local and remote operation; automatic and manual devices are all utilized. The efficiency of a system is generally measured in the results achieved rather than in the power consumption of the equipment. But all these factors, interesting though they may be, do not necessarily determine the quality of any installation. It is necessary to first know what is most important in a specific case.

Resistance & Transformer Dimmers

In the category of amplitude control there are two basic types of control devices: resistances and transformers. Each has taken several forms. Although it may come as a surprise to many, the original resistance dimmer was a liquid unit—what was known as a "water-barrel dimmer." A vertical insulating cylinder with a conductive plate at its lower end was filled with a liquid electrolyte. A second plate was then mounted on an adjustable holder so that it could be raised

Fig. 1. Waveforms from various types of dimmers. All inputs are sinusoidal; all outputs are shown shaded. (A) At full intensity, output from dimmer is same as input. (B) With resistance or autotransformer dimmer, output amplitude is reduced as shown. (C) With electronic dimmer, output occurs over part of cycle.



or lowered in the liquid. As the two plates approached one another, resistance decreased and the voltage drop between them decreased. The intensity of the lamp load in series with the dimmer then increased.

This device had many obvious disadvantages, but it had its good points too. By varying the consistency of the electrolyte, various loads could be accommodated and dimmed to "black-out." The "dimming curve"—rate of voltage variation across the load with respect to the position of the controller—could be changed. The total load which could be accommodated was easily adjusted, but changes due to humidity and time, a vile odor, low efficiency due to heating, unreliability—all were to spell the eventual doom of the water-barrel dimmer.

Wirewound and carbon-pile rheostats were definite improvements over the water barrels and are still used where resistance-only units are applicable. Although carbon piles have never been popular in lighting control, they have been used on occasion. Carbon discs are pressed more or less tightly together to decrease or increase the resistance in the series circuit. The wirewound types include units where wipers ride directly on the wire, and tapped coils where wire supplies the resistance but mechanical contact is made between a shoe or brush and solid metal terminals. Both of these devices introduce electrical losses. That portion of the line voltage not appearing across the lamps appears across the rheostat. Thus, the resultant power loss must be dissipated in the form of heat. Such units are extremely "load sensitive." Any change in lamp wattage causes a change in the rheostat current and, hence, a change in the voltage at the lamps. While various dimming characteristics are easily designed into a rheostat, they are true for only one load or lamp size. Rheostats for heavy loads become exceedingly large and clumsy to handle.

Variable transformers largely overcome these disadvantages, but may introduce others. It is obvious that to be really useful a dimmer's action must be smooth and continuous. It should not generally provide a series of "steps" or gradations of intensity unless these steps represent voltages too small to be apparent to the eye. These can be produced if a sufficient number of taps or secondary turns is available. But even with the requisite number of steps, the "tap" or "shoe" which selects them must make contact with one before leaving the last if a continuous dimming curve is to be provided. This results in shorted turns, producing high circulating currents and commutation difficulties.

Two methods have been developed to overcome this problem. In one, a number of fixed resistances are connected to a series of shoes or taps, each of which contacts a different turn of the transformer winding. At least two of these resistances are in series for each relatively low voltage short-circuit current, while all are in parallel for the load current. A modification of this principle consists of a special carbon brush or tap which contacts more than one transformer winding at any given time. The carbon takes the place of the individual resistors and the heat developed by the short-circuiting currents is dissipated in a metal "radiator" carrying the brush. The second solution consists of a plurality of contacts each connected to the next by a single turn of wire which surrounds the same core as the transformer coil being tapped. Thus, the voltage between taps exactly equals the voltage across the turns being tapped, and the voltage tending to produce short-circuit currents is "bucked" by an equal and opposite voltage.

Transformer dimmers—almost always of the autotransformer type—are far more efficient than resistances. Being essentially voltage controllers, they are largely unaffected by variations in load. They can be tapered to provide various desired dimming characteristics and are stable. However, they are also relatively heavy and physically large. They must be controlled manually (directly) or by means of motor drives if they are to be located at a distance. In addition, they are not capable of proportional control without expensive modifications.

Induction regulators of the movable-core type, although used for power control, were never popular for lighting installations. Their only application in any quantity has been in pilot circuits where the change in inductance is used to control small currents, in turn controlling larger loads through other types of dimmers. Such devices are used as "group master" controls in New York's Radio City Music Hall lighting control console and other installations.

Saturable Reactors

The introduction of true electronic dimmers in the 1930's, although the equipment was large and heavy, represented a major breakthrough in lighting control. The first device of this type was the saturable reactor. Here a figure-8 core is wound with power turns through which passes the full load current. Core and windings are so designed that with the normal load which the device is designed to carry, the reactance will effectively limit the load current. By introducing a second winding which is connected to a variable source of d.c., the core may be partially or completely saturated, permitting almost uninterrupted flow of the load current. Thus, a relatively small d.c. can be used to control large alternating load currents.

Although such devices are infrequently used in numbers throughout a modern system because of certain inherent disadvantages (such as slowness of response, size, weight, etc.), they still have their place in modern lighting control. Where very large loads must be handled and dimming to complete "black-out" is not required, the saturable reactor dimmer is a relatively inexpensive and foolproof piece of equipment. In the control of peripheral lights at the Philharmonic Hall in New York City, saturable reactors were chosen. They are also used in Detroit's *Michigan Consolidated Gas Company* building. Loads are in the neighborhood of 300 kva.

Thyratron Dimmers

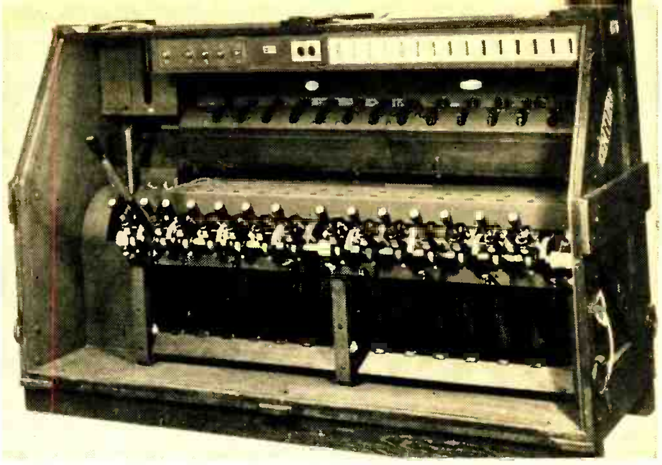
But a more precise control and one suitable to smaller installations was required. The answer was the thyratron or gas-filled, grid-controlled rectifier tube. For many years an electronic dimmer almost always was a thyratron tube dimmer. Two basic configurations were used in the power circuit. In one, three tubes were installed in the line of a three-phase system and the dimmer was, in effect, a variable three-phase rectifier. The second and more popular circuit utilized two tubes, connected back-to-back, in a single-phase line. In this circuit the output was a.c.; the r.m.s. voltage be-

Thyratron tube dimmer bank with 60 tubes providing 30 control circuits. Each dimmer or pair of tubes has a capacity of 5000 watts. The bank shown is approximately 80" wide and 80" high.

ing controlled by the point during each half cycle at which that tube fired. This firing point or "firing angle" was established and varied by an *RC* network where a vacuum tube took the place of the resistance. By controlling the vacuum tube, the phase of the thyratron's grid control could be shifted and the r.m.s. output changed from zero to nearly line voltage. However, in practice, a booster transformer was always introduced to compensate for the drop across the tubes and provide additional voltage for feedback operation to improve regulation.

The thyratron tube dimmer is still being chosen for certain applications, but is being superseded rapidly by solid-state devices. It still has certain advantages over the more recently introduced semiconductors; also disadvantages. Response is very rapid. No contactors are required to turn a circuit "off." Voltage transients and sudden current surges are generally of no concern. But in a tube system, in order to operate any one circuit all filaments must be energized, representing a considerable loss in heating. A filament preheat time of 40 seconds or more must be established before plate voltage can be applied. Provisions must also be made for disconnecting the entire system and going through an entire preheating cycle again should temporary loss of power be experienced. The most obvious disadvantage often mentioned—cost of tube replacement—is not as serious as might be expected, for tube life in excess of 10,000 hours is common.

A 2500-watt autotransformer dimmer designed for manual operation through a drum and lever and a gear drive.



"Piano box" resistance dimmer board such as is used in theater productions where only d.c. is available. Fourteen 3000-watt dimmer rheostats are operated by lever handles across the front, any of which can be interlocked with the master lever. A main switch, individual circuit switches and fuses, and load receptacles are provided. Board is 7' x 5' and weighs 1350 pounds.

Magnetic Amplifiers

During World War II the magnetic amplifier or self-saturating reactor was developed. Improvements in metallurgy and production of grain-oriented steels plus solid-state power rectifiers overcame many of the disadvantages of the old saturable reactors. Magnetic amplifiers, or "Mag-Amps," for light control are now available in capacities up to 12 kw. per unit, with response times almost equal to those of tube systems. The sizes and weights of these dimmers have also been drastically reduced, and temporary overloads, relatively high ambient temperatures, and the surges due to sudden applications of cold tungsten filament lamp loads have little or no effect on the operation.

But the magnetic amplifier dimmer was developed too late, or one might say that solid-state semiconductors were developed too soon. For already, only a few years after the announcement of the silicon controlled rectifier, the majority of electronic dimming systems built and installed utilized this device in preference to all others. It has its disadvantages as have the rest, but the possibilities of precise control, the savings in space and weight, and the recent reductions in price have made these units serious competitors of manually controlled rheostats and autotransformers.

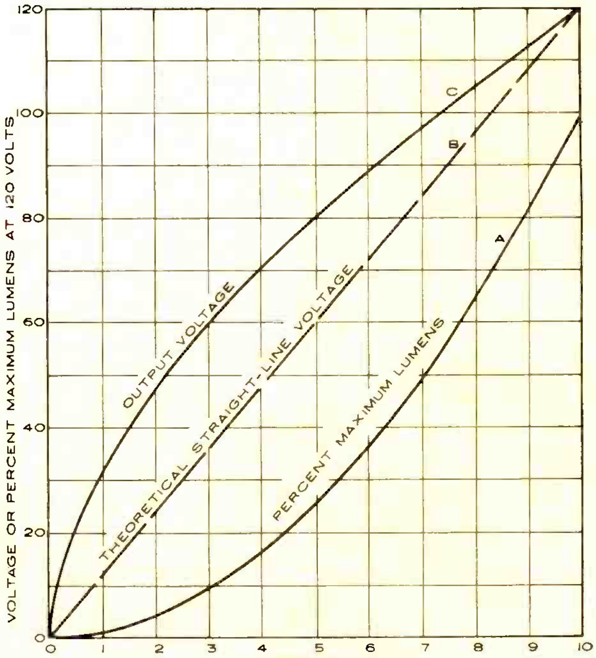
SCR Dimmers

A description of silicon controlled rectifiers and their characteristics may be found in the article, "SCR: Silicon Controlled Rectifiers—New Applications in the Home" in the October 1963 issue of this magazine. However, when applied to the control of tungsten filament lamps, other factors not always considered become important. Certain features of these loads must be recognized before a circuit can be selected. First of all, tungsten filament lamps have the unfortunate characteristic of low cold resistance *versus* relatively high hot resistance. The initial inrush current through a cold lamp load for several cycles is between ten and fifteen times normal operating current once the lamp is heated and burning at specified brightness. This must be taken into consideration in determining the size rectifier required for any given application. It is one reason why solid-state "wall-box" dimmers bear the warning that they are not to be used for the control of convenience receptacles where one or more lamps may be plugged in while the dimmer is turned on.

Tungsten filament lamps also have rather peculiar dimming curves—their ratio of light output to applied voltage. In many applications this is relatively unimportant. Where a single reading lamp or fixture is to be adjusted or dimmed to a desired level, the point on the control scale or "dimmer reading" selected is simply wherever the intensity happens to suit. However, in large dimming systems such as are used in theaters, studios, and the like, each dimmer control must control at exactly the same rate and utilize to the fullest the entire scale of the controller. Moreover, this should be irrespective of loading, and a set intensity should not vary even while loads are being added or removed. See Fig. 2.

Particularly in television studios and other areas where audio and video equipment are located in close proximity to lighting, care must be taken to remove both electrical and audible noise from the lamp circuits. The filaments of most

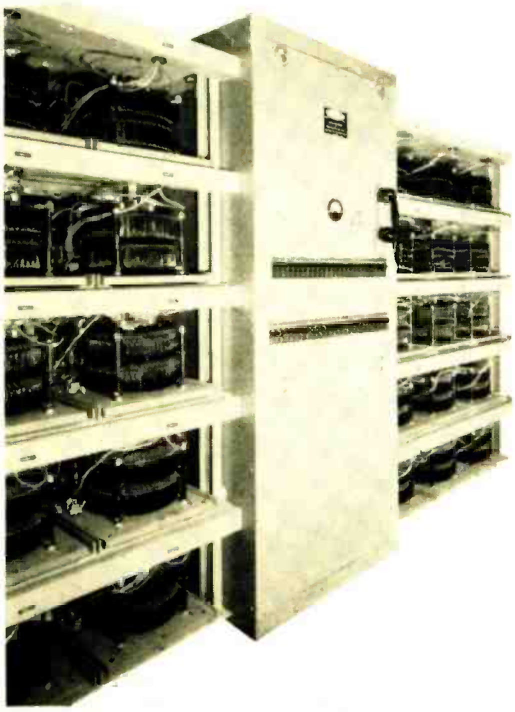
Fig. 2. Curve A is the ideal variation in light output vs control settings. This is a square-law curve and takes into account the varying sensitivity of the eye at different light levels. Since light output does not vary in direct proportion to dimmer output voltage, a voltage characteristic shown at C is required to produce the light output curve A. Note how the output voltage differs from a voltage that varies linearly with setting (curve B).



lamps will sing or hum when fed by the unfiltered output of any electronic dimmer, particularly at half voltage.

Harmonics are also present unless special precautions have been taken. These will cause trouble both in radiated noise and electrical noise transmitted through the circuits themselves. The sharp peaks of outputs from controlled rectifier dimmers must be modified for satisfactory operation.

In addition to the difficulties introduced by the lamp loads, controlled rectifiers themselves present problems which are unique in dimmers. Together with their sensitivity to momentary overloading, they are highly sensitive to voltage transients. A transient during conduction and in the forward direction may not necessarily be serious. A reverse peak will cause destruction of the device. The cost of an SCR is largely determined by its p.r.v., or peak-reverse voltage, capability. But the highest ratings available are hardly capable of sustaining transients which may be imposed by air conditioners, elevators, or an electric storm in the neighborhood. Some



This installation includes 30 6.3-kw. magnetic amplifier dimmers, at either side of control cubicle which houses a booster transformer, motor-driven autotransformers, circuit breakers.

other means of overcoming these momentary peaks must be found.

Like most semiconductors, an SCR's current-carrying capability is largely determined by the temperature of its junction. The cooler this is kept, the greater the currents which may be accommodated. Hence, heat sinking is an economic necessity and artificial refrigeration has even been considered.

Summing up the above points concerning silicon controlled rectifier dimmers, it appears that while they possess many advantages over other devices they are also relatively fragile under certain conditions and require numerous protective devices. A simple SCR voltage controller is not necessarily a good or even a satisfactory dimmer.

Solid-State Switches

A still more recent development in solid-state technology is the solid-state switch. This is a five-layer device as compared with the four layers of the controlled rectifier, but it has only two leads. There is no gate connection. Like the controlled rectifier, the solid-state switch normally blocks in both directions but, unlike the rectifier, it can be made to avalanche in either direction. Because it has no gate lead, it is rendered conductive or can be made to avalanche by merely exceeding its breakdown voltage in either direction. Once conductive, it will remain so until the current drops below a specified holding value when the device resumes its normal blocking condition.*

The solid-state switch overcomes two disadvantages of controlled rectifiers: (a) transients may cause false conduction for a half cycle now and then but will not destroy the switch, and (b) one unit in a circuit can be used to control the full 360° of each a.c. cycle. But, like all the other devices we have mentioned, it is not the ultimate. Solid-state switches are presently made in only smaller ratings. Units are sometimes paralleled to provide greater capacity, but they must be carefully matched to prevent one taking more than its share of the load current. Also, the introduction of high-voltage spikes or pulses to render the device conductive must be limited to the circuit of that device. Where several dimmers are used in a system, the control of one must never be allowed to influence another. These disadvantages are not unduly restrictive in many applications and can certainly be overcome. At present, the few sizes which are in production offer the only real competition for SCR's. In the multi-kilowatt control range, solid-state switches have yet to be seriously considered.

Table 1 shows many of the advantages and disadvantages that have been mentioned as well as several which are of interest only in specific applications. However, the advantages of solid-state semiconductor devices are sufficiently great to warrant a closer examination of the circuits which have been developed to operate them. After the first exuberance in discovery of a new dimmer with such rosy possibilities gave way to serious thought, it was realized that the requisite auxiliary equipment was going to be considerably larger in space and weight (and possibly eventually in cost) than the "dimmer" itself. The number and variety of circuits for controlling SCR's in incandescent light dimmers are almost endless and far beyond the scope of this article. The examples given are illustrative and merely indicate some methods of overcoming the difficulties which have been mentioned and of utilizing the advantages of the devices.

Dimmer Circuitry

Fig. 3 shows a bridge circuit in which a single SCR controls both halves of the a.c. wave. It will be realized that this power circuit may or may not be desirable economically, depending upon the relative cost of four diodes as against

*Since writing this article, a new solid-state switch with a gate lead has been introduced. It can be controlled either by exceeding the breakdown voltage or by gate control voltage alone. It conducts in both directions with signal and blocks in both directions with zero control.

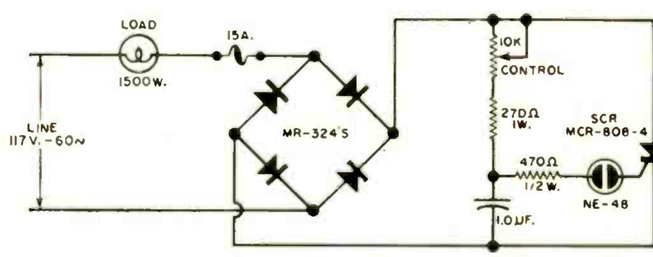
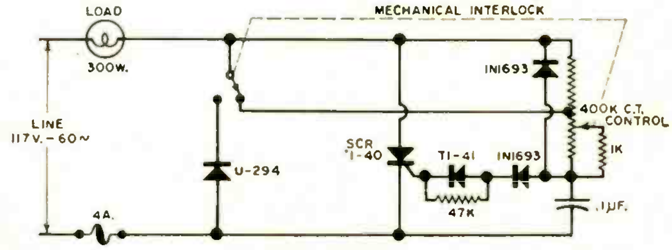


Fig. 3. Simple dimmer circuit designed for 1500-watt load.

Fig. 4. Dimmer circuit with one SCR and transfer switch.



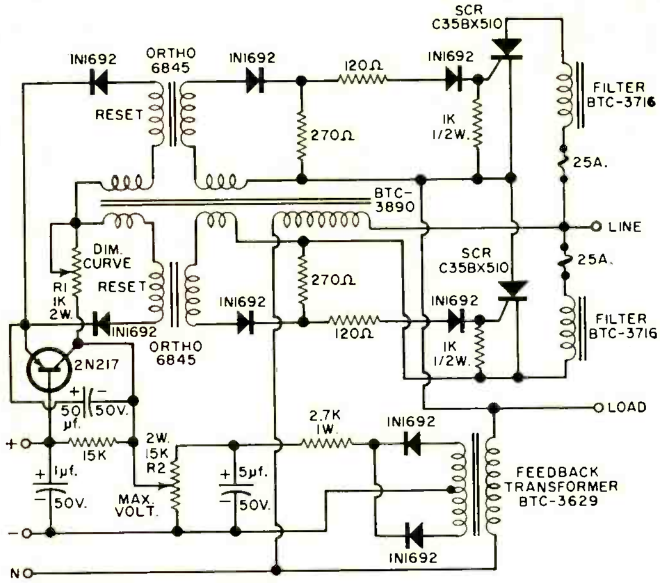


Fig. 5. Controlled-rectifier dimmer with back-to-back power connections and reset triggering circuit. Circuit is controlled by 20 v. d.c. connected to plus and minus terminals. Voltage comes from a 1000-ohm pot in control console. The two controls shown are internal controls set for desired dimmer characteristics.

a second SCR used in the more common back-to-back configuration. However, from the control component standpoint, nothing could be simpler. When the resistance of the control is at maximum, the voltage across the capacitor is sufficient to break down the neon lamp and trigger the SCR at about 150°. This occurs twice during each cycle. As the control resistance decreases, the voltage across the capacitor increases and becomes less lagging in phase. Thus, the SCR is fired earlier in each half cycle and lamp intensity increases. A *p-n-p-n* diode may be used in place of the neon lamp and fixed resistor. In applications where full variation of intensity is not required, the full-wave bridge may be omitted entirely. This greatly reduces the cost of the circuit. However, a gate protection diode should be added between the gate and cathode of the SCR.

Full-intensity control, still with a single controlled rectifier, is shown in Fig. 4. Here, by ganging a single-pole, double-throw switch to the potentiometer control, the controlled rectifier is made to operate over half of each cycle. The power diode is then switched into the circuit and the other half of the wave is controlled until full intensity is reached. The resistor across the *p-n-p-n* diode (TI-41) and the diode across the potentiometer prevent flickering caused by the capacitor storing a charge from one cycle to the next.

Another method of controlling SCR's is by means of magnetic amplifiers or resets. A circuit used in many commercial dimmers is shown in Fig. 5. The resets are torroids and the transistor stage provides a preamplifier which greatly reduces the control current required. In this circuit, a feedback loop is also provided in order to give improved regulation under a fairly wide variety of output loads.

Protective Measures

Several methods have been devised by various dimmer manufacturers for providing complete protection of the SCR's and other solid-state components regardless of the loads applied. These include:

1. Phase-back circuits which automatically reduce the r.m.s. values of current when excessive loads are connected—either initially or on operating loads. (*Continued on page* 68)

Table 1. Features and comparative characteristics of the various types of light dimmers described in the text. ▶

Features	Resistance Dimmer	Autoxfmr. Dimmer	Saturable-Reactor Dimmer	Thyratron Dimmer	Magnetic-Amp. Dimmer	Controlled-Rect. Dimmer*	Solid-State-Switch Dimmer
Capacity (watts)	100-5000	Up to 60,000	Only large sizes available today	Up to 6000	Up to 12,000	Up to 12,000	Up to 2500
Physical size	Large	Large	Very large	Moderately large	Moderately large	Small	Small to very small
Weight	Heavy with respect to capacity	Slightly lighter than resist.	Very heavy	Comparable to autotransformers	Heavy	Lightest available	Very light for capacity
Cost	Relatively high due to small demand	Lowest of all manual units	Relatively low in large sizes; not economical in small	Tube cost high; control circuits moderate	Comparable to tube type; less per kw. in larger sizes	Lowest of electronic types	Lowest in capacity range
Reliability	Very good	Very good	Good	Good	Good	Improving all the time; now good	Good when properly applied
Stability	No drift or oscillation	Excellent	Good	Very good	No drift or oscillation when properly adjusted	Most are good	Most are good
Electrical efficiency	Poor	Excellent	Very good	90%	Good	Excellent	Excellent
Regulation	Very poor	Excellent	Poor	Very good	Good except when very lightly loaded	Can be made very good	Generally excellent
Dimming Curve	Good for given size load	Generally linear but some tapered	Depends on curve of d.c. control current	Generally linear with slight "S" at either end	Generally linear	Can be adjusted in some units to curve desired	Generally linear and non-adjustable
Remote control	Only with motor drive	Only with motor drive	Pilot type on d.c. source	Pilot type; very low control current and voltage	Pilot type; never manual or local	Pilot type; low current and voltage; sometimes locally controlled	Local control in wall boxes; can be pilot remote type
Speed of response	Instantaneous	Instantaneous	Slow	Very fast	Quite fast but not always the same for all loads	Very fast but not always the same for all loads	Generally fast
Noise	None	Very slight dimmer hum	Dimmer hums	Dimmer hums; filter outputs	Dimmer hums; some noise from lamps	Dimmer quiet; output must be filtered	Dimmer quiet; output should be filtered when necessary
Protection	Fuse or circuit breaker	Fuse or circuit breaker	Circuit breakers	Circuit breakers	Circuit breakers or preferably fuses	Breakers or integral fuses or special circuits	Fuses or special circuits

**Characteristics vary widely from one unit to another, depending on particular manufacturer's circuitry.*

NEW FCC RULES NOW IN EFFECT

By LEO G. SANDS

Changes in the FCC Rules and Regulations went into effect December 21, 1963. Here is a breakdown of these changes and how they may affect many users.

The FCC Rules changes provide for:

- **changes in Rules part numbers**
- **use of SSB on some marine channels**
- **two ½-watt Business Radio channels**
- **new offset channels for Industrial Service**
- **11 narrow-band channels for Industrial Service**
- **operation of fixed radio links on low-power, general-purpose mobile channels**
- **use of non type-accepted transmitters operated at less than 200 mw. input**
- **use of 952-960 mc. for base-station control, and 6525-6875 mc. band for private microwave systems in the Business Radio Service**

REVISED FCC Rules and Regulations affecting marine, aviation, land mobile, amateur and Citizens Radio were published in the December 21, 1963 issue of the Federal Register.

The Citizens Radio Service is no longer covered by Part 19, instead, it is now covered by Part 95. The other service part numbers have been changed as follows: Maritime Land Stations from Part 7 to Part 81; Maritime Mobile from Part 8 to Part 83; Aviation from Part 9 to Part 87; Public Safety from Part 10 to Part 89; Industrial, which includes Business Radio, from Part 11 to Part 91; Amateur from Part 12 to Part 97; and Land Transportation from Part 16 to Part 93.

The new rules are essentially the same as they were before except for some tightening of technical tolerances and addition of channels. In the Business Radio Service, for example, two new channels have been allocated for use by transmitters limited in power to one-half watt input. On these channels, low-power, short-range devices are protected from interference by higher-powered transmitters.

Because of the great demand for Business Radio Service channels and the congestion that is occurring on them in some areas, the new rules state that the FCC may allocate additional channels above 150 mc. which are offset from those presently listed in channel tables for the Industrial Radio Service. In addition, ten narrow-band channels have been added which are available under a developmental license. Instead of specifying the channel center frequency, the rules list the limits within which radio emissions must be confined, as follows: 30.56-30.57, 35.00-35.01, 35.19-35.20, 35.68-35.69, 35.99-36.00, 37.00-37.01, 154.4600-154.4675, 173.2000-173.2075, 173.2075-173.2125, 173.3875-173.3925, and 173.3925-173.4000, all in megacycles. On the six low-band channels, 10 kc. of band occupancy is allowed, with 7.5 kc. on the five high-band channels. Because of the very narrow band limits, the use of AM or SSB is indicated, although FM with very small frequency deviation is feasible but not necessarily very effective. However, these channels might be of value for new FM-SSB equipment now being developed which occupies only half as much band space as conventional FM.

Also affecting the Business Radio Service is the requirement that availability of any channel whose immediately adjacent channels are not also available to the Business Radio Service depends upon proper frequency coordination. This means that the license application must be accompanied by an engineering report that shows the degree of probable interference to existing stations in the same area plus a signed statement that all existing stations operating within 15 kc. of the desired frequency, located within a 75-mile radius of the location of the proposed station, have been notified. In lieu of such a report and statement, the use of the frequency must be approved by a frequency coordinating committee.

Heretofore, a prospective business radio user could decide for himself, or follow the recommendations of a mobile radio equipment salesman, as to which band or channel he wished to operate in. The new rules state that the applicant shall use the highest order of frequencies available, compatible with his operational and range requirements, as well as actual channel loading conditions in his area of intended operation. First cost and maintenance expense *will not be considered* in approving a choice between operation in the 25-50-mc. low band, the 150-174-mc. high band, or the 450-470-mc. u.h.f. band.

If this is enforced, those who require only short-range communication might be eligible for a license only in the u.h.f. band even if equipment cost is higher. However, the industry itself has already given the use of u.h.f. band a big push. Practically every manufacturer of low-band and high-band equipment who does not now have u.h.f. band equipment has expressed (*Continued on page* 60)

FCC Rule Part Number Changes

Class of Service	Old Rules Part No.	New Rules Part No.
Maritime Land	7	81
Maritime Mobile	8	83
Aviation	9	87
Public Safety	10	89
Industrial	11	91
Amateur	12	97
Public Fixed (Alaska)	14	85
Land Transportation	16	93
Citizens	19	95
Disaster	20	99

THE MICROPHONE SENSITIVITY RATING

By ROBERT C. RAMSEY
Chief Engineer, Microphones, Electro-Voice, Inc.

Standard methods used by industry to specify sensitivity plus nomogram of output voltage for various impedances.

Editor's Note: The following material from Electro-Voice's "Microphone Facts" should be of considerable interest to our readers who use microphones in recording, broadcasting, or communications. It should clear up some of the misunderstanding that exists over the sensitivity specs that are given by the manufacturers.

THERE are two methods in general use throughout the microphone industry for specifying sensitivity. For low-impedance microphones, the electrical output is given in db referenced to 1 milliwatt for 10 dynes/cm.^{2} sound pressure. For high-impedance microphones and carbon microphones, the electrical output is given in db referenced to 1 volt for 1 dyne/cm.^{2} sound pressure. Note that both an acoustic input and an electrical output are specified. In this respect, a microphone can be considered a generator with sound-pressure input and a voltage or power output.

These ratings can refer to one specific frequency or band of frequencies. Two commonly used frequencies are 1000 cps and 250 cps. The 1000-cps measurement is used for communications-type microphones where only speech frequencies are involved. The 250-cps measurement is used for wide-range microphones that may be used to pick up music.

Low-Impedance Mikes

For low-impedance microphones, we specify a power output. Since the impedance of these microphones is quite often transformed to a higher value at the input circuit, the output is given as a power output which does not change when the impedance is transformed (transformer loss is usually less than 1 db). Consider, as an example, a low-impedance microphone with a sensitivity rating of -60 db re 1 mw./10 dynes/cm.^{2} for which we wish to determine the voltage output at the grid of the input stage. Visualize the microphone as a generator, as shown in the inset diagram at the right.

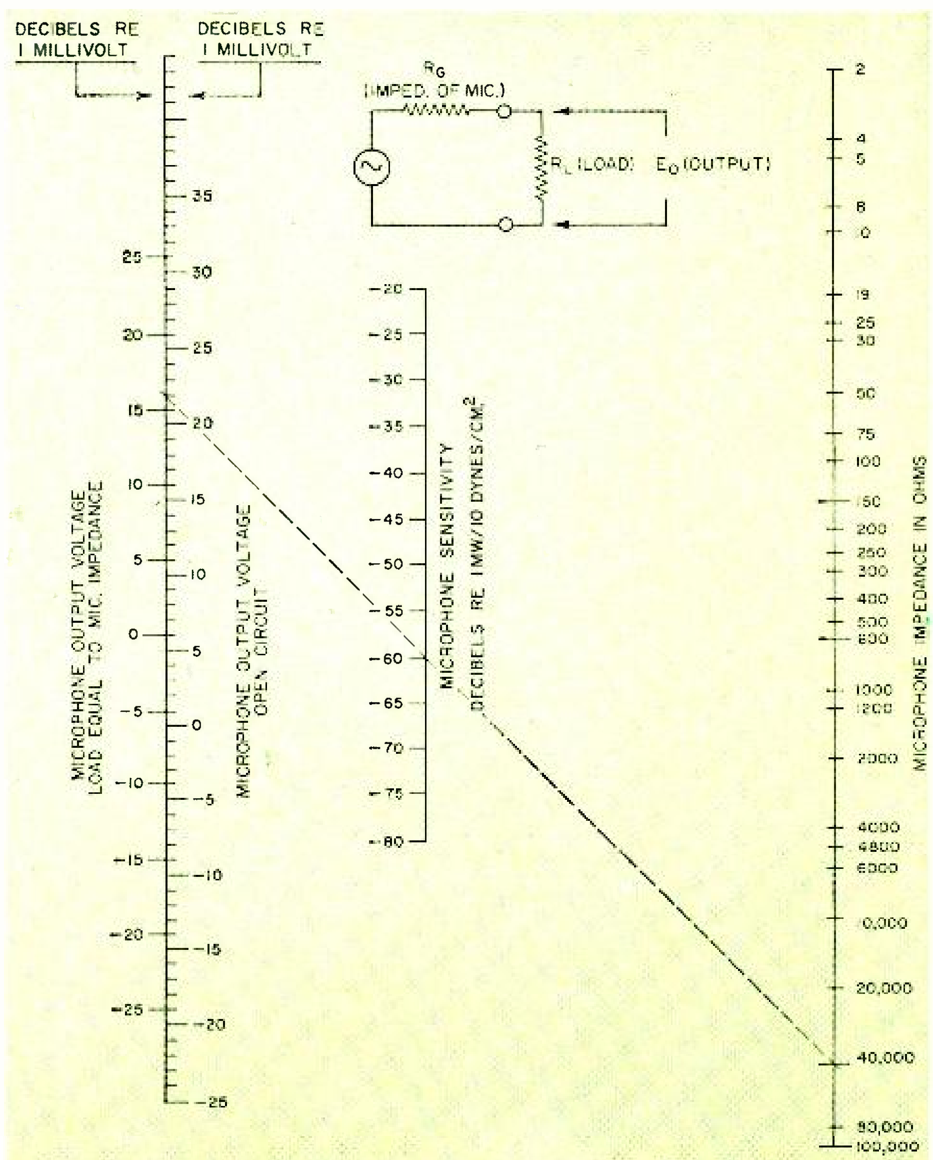
The sensitivity rating of -60 db means that with 10 dynes/cm.^{2} sound-pressure input, the microphone will deliver to a resistive load, equal to the impedance of the microphone, a power of 10^{-9} watt (one-millionth of a milliwatt or $10^{-6} \times 10^{-3}$). Since $P = E_o^2/R_L$, then $E_o^2 = 10^{-9} R_L$.

$$E_o = 3.16 \times 10^{-5} \times \sqrt{R_L}$$

For an impedance at the grid of the first stage of 40,000 ohms, the output would be: $E_o = 3.16 \times 10^{-5} \times 200 = 0.00632$ volt or 6.32 mv. (for 10 dynes/cm.^{2} sound pressure). If the microphone is used open-circuited, the voltage output would be twice this value.

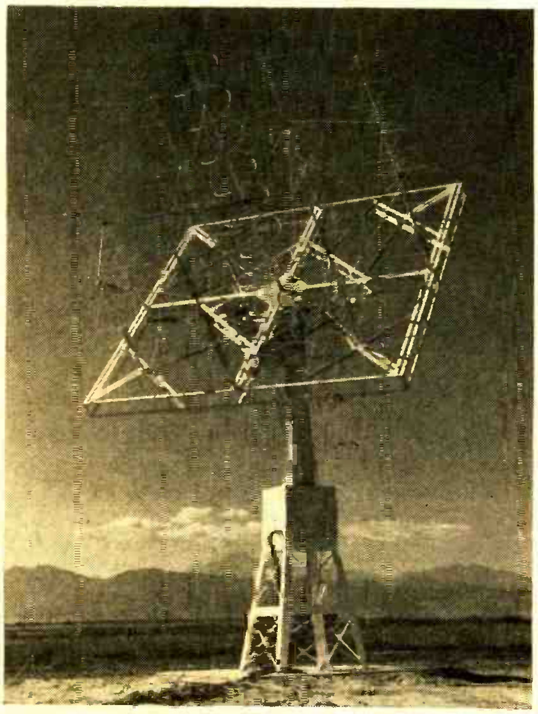
Nomogram

A quick-reference chart showing (*Continued on page* 75)



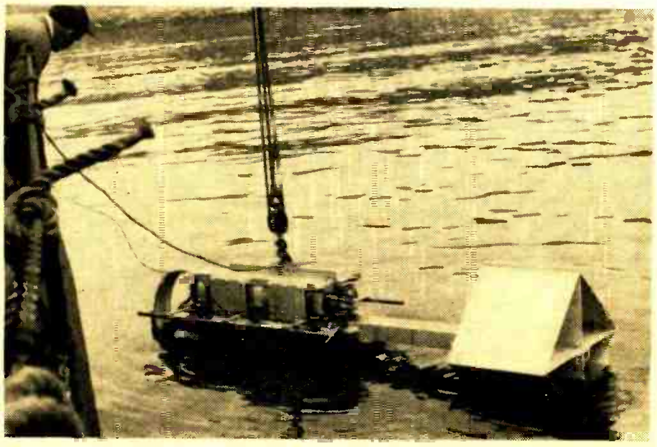
RECENT DEVELOPMENTS in ELECTRONICS

Medical Computer Charts Eye Motion. (Above) Photocells built into a special eyeglass mounting arrangement are being used to detect eye movements as the technician follows a moving target. The work is taking place at the Massachusetts Eye and Ear Infirmary. The signals being generated are fed directly by wire to a G-E computer at MIT. Here the data is automatically processed, analyzed, and then returned to the hospital in a form that is suitable for use by the physicians.



Telemetry Antenna for Topsi. (Above) This new antenna array at the National Bureau of Standards' Gunbarrel Hill, Colo. field station will be used to communicate with Topsi, a topside sounder satellite to be launched by NASA this year. The array consists of eight yagi antennas for receiving telemetered data and a single helix for transmitting instructions to the satellite. All are mounted on a frame which is turned and elevated in use so that it is always pointed at the satellite during flight.

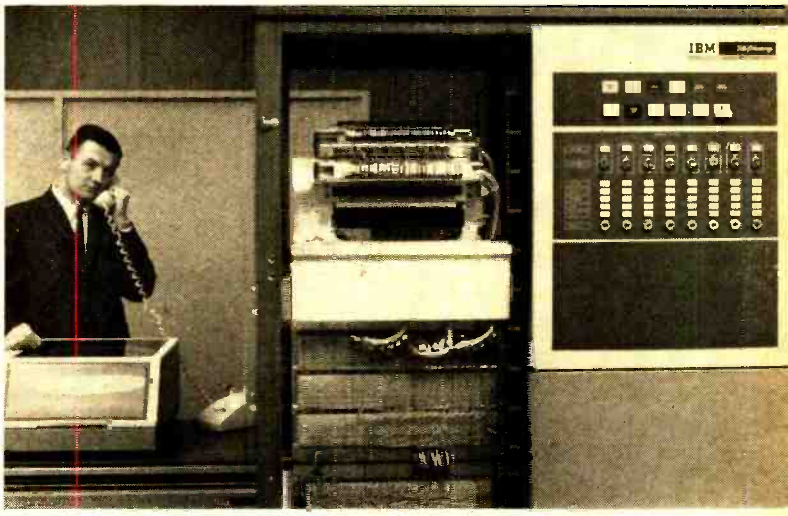
Remotely Controlled Mobile Robot. (Above) The Mobot, manufactured by Hughes Aircraft, is sent through final checkout before delivery to the National Reactor Testing Station, Idaho. Here it will perform clean-up operations. Control commands from operator's console (left) are carried through a cable permitting vehicle to rove up to 500 feet away. TV monitors allow operator to see what robot's closed-circuit TV cameras see . . . **Sonar Picture Taker.** (Left) Shown entering the water for underwater tests, this Westinghouse sonar search vehicle can map the ocean floor at depths down to 20,000 feet. Information from the vehicle is transmitted by coax to a surface ship, which carries the display equipment and tows the vehicle at speeds up to 4 knots. The "side-looking" sonar has a range of 2400 ft. at right angles to the direction of tow and produces detailed pictures.



Portable TV Camera. (Right) A transistorized TV broadcast system, which gives cameramen the mobility of spectators at sports and other news events, was demonstrated recently by Sylvania. The system, called the "Newschief," was used by ABC to televise the 1964 Winter Olympics in Innsbruck, Austria earlier this year. The entire equipment weighs less than 30 pounds and is powered by a rechargeable nickel cadmium battery that operates for about an hour. A solid-state 2000-mc. transmitter develops 1 watt of power output into the omnidirectional antenna mounted atop a 2-foot mast. Range of the equipment is up to 1 mile. The camera itself is a modification of the company's 800-line CCTV camera; it weighs about 5 lbs. The back pack houses sync generator, amplifiers, and the video and sound transmitter.

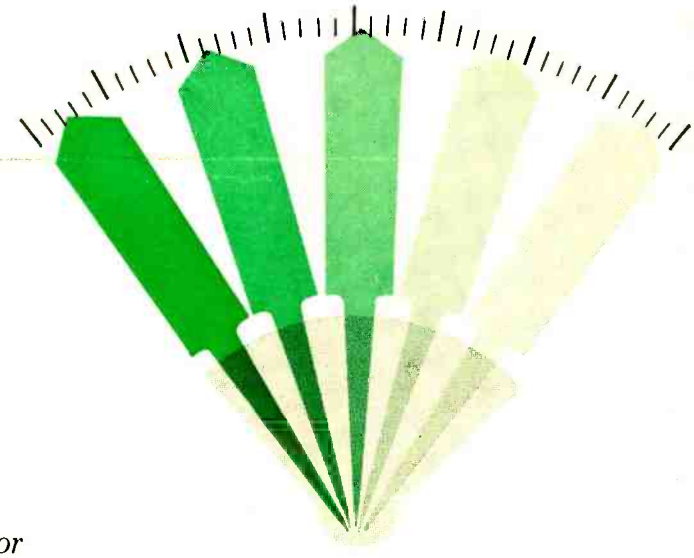
Magnetic-Card Storage. (Left) As pages in the volumes shown hold facts, so data is held on magnetic cards in RCA's new Random Access Computer Equipment (RACE). A single, flexible plastic card contains 166,000 characters of data on a flat magnetic surface 16 inches long and 4½ inches wide. The card has 128 recording channels, separated into addressable blocks. Each card is distinctively edge-notched for purposes of selection. Some 256 cards go to make up one magazine and there are eight such magazines in each RACE unit (background). All the characters printed in the volumes, over 1¼ billion, could be contained in four such units. Data is accessible in a fraction of a second.

Computer Talks Back. (Right) The engineer is getting a telephone reply to an information inquiry from the new IBM 7770 audio response unit. The unit obtains information from a computer in response to dialed telephone inquiry and provides an answer over the telephone in the form of spoken words. The computer assembles proper words from a recorded vocabulary of 127 words stored on a magnetic recording drum (center), amplifies them, and transmits them back over the dialing phone. Information needed to answer requests may be stored on a disc storage unit at left in photo.



Longest Laser. (Left) The longest laser ever built is this 33-foot gas laser at Bell Telephone Laboratories. The tube can be emptied and refilled with various gases. Here an experiment is being conducted on a helium-neon laser to measure the power of the light beam. The extraordinary length makes possible a greater amplification of the laser beam each time it travels the length of the tube. Mirrors at each end reflect the beam back and forth before a portion of it exits at the ends. With the increased amplification from the long laser, it is possible to observe much weaker oscillations.

ELECTRONIC TACHOMETERS



By JIM KYLE

Operation and calibration of relay and transistor tachs that are used to measure car engine rpm's.

ONE of the most important dashboard instruments for the serious driver is the tachometer—although a tach is standard equipment on only a few vehicles. For all other autos, the tach must be added as an accessory item.

The standard of the accessory-tach field is the electronic tachometer, although you couldn't tell it by a quick trip through your auto-supply store. Motorcar people call it an "electric" tachometer.

Accessory tachometers are made by a number of firms. One of the recognized leaders in the field is *Sun Electric Corporation* of Chicago, which builds most of the tachs used by top competition drivers. Active as well in this field are: *Airguide Instrument Company*, also of Chicago, and *Sparkomatic Corporation*, Milford, Pa. Other entries include *Dixon Products Inc.*, Vashon, Washington; *Allied Radio Corporation* ("Knight-Kit"), Chicago; *Heath Company*, Benton Harbor, Michigan; *Lafayette Radio*, Syosset, N.Y.; and others.

Although specific technical details are not available on all of these instruments, there is an indication that all except *Sun* use similar basic circuits employing either one or two transistors. *Sun's* competition models do not use transistors; instead, a precision relay is employed. However, *Sun* does make one model (FZ) which uses a single-transistor circuit.

Before going into the details of these circuits, perhaps we should look at the tachometer problem. The tach must measure revolutions per minute of the engine's crankshaft and display it as a dial reading on the dashboard. A number of ways of doing this are available.

Types of Tachometers

One of the earliest was the "mechanical" tach which used no electrical or electronic components. Two models were employed. One was similar to a speedometer, in which a rotating magnet "drags" the pointer against spring pressure. This type suffers from limited accuracy, since as the magnet ages it may lose some of its force. The other was similar to a flyball governor, in which two weights were hinged to a rotating shaft so that the faster the shaft turned, the farther the weights would swing from the shaft. The movement of the weights was then translated, by linkage, to needle movement on a dial.

Both types of mechanical tachometers suffered a severe disadvantage, which has limited their application. This disadvantage is the necessity for a mechanical, rotating-shaft hookup to the auto engine.

The next step was the true "electrical" tach, which eliminated the rotating shaft but still required a mechanical connection to the engine. This type of tach consisted of a d.c. generator attached to the engine, and a voltmeter on the dashboard. Output voltage of the generator is proportional to engine speed, so the voltmeter could be calibrated in rpm.

The electrical tach is still used in some industrial applications, but the requirement for mechanical connection to the engine made it unattractive for auto-accessory use.

The final solution, to date, has been the electronic tachometer which requires no mechanical hookup at all. It operates from the ignition pulse produced every time the breaker points open and a sparkplug fires. These pulses bear a definite relationship to engine speed. The faster the engine is turning, the more often the pulses are produced. Thus, if electronic circuitry to count the number of pulses produced per second is connected to the ignition system, rpm can be read directly on a meter.

Here's how it works, in general: The ignition pulse is

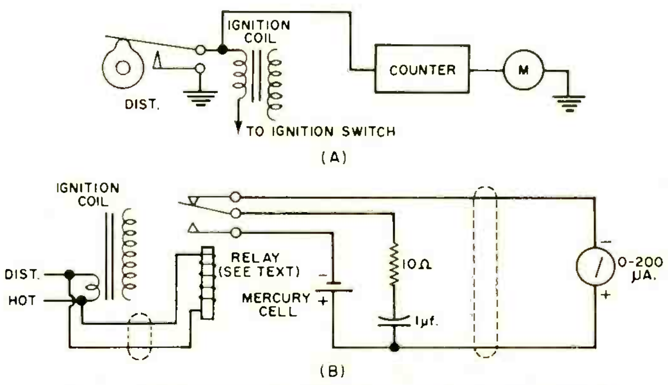
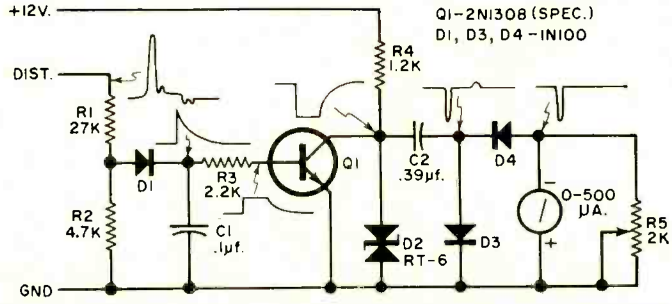


Fig. 1. (A) Basic circuit. (B) Relay-type tachometer circuit.

Fig. 2. Transistorized tachometer with operating waveforms.



taken off at the distributor breaker point-to-coil connection in the auto electrical system and applied to a "counter" circuit (Fig. 1). The counter produces an output voltage or current proportional to the frequency of incoming pulses, and this counter output goes to a dash-mounted meter calibrated in rpm.

The differences between tachometers are primarily in the counter circuits employed. To see how they work at the most basic level, let us first consider the circuit diagram shown in Fig. 1B which is similar to that employed by *Sun* in its competition model tachometers.

Relay Type

Between ignition pulses, the distributor cam allows the breaker points to close, grounding the ignition coil. Once each firing cycle, the points open, firing the coil.

A sensitive, fast-acting relay in the tachometer is connected in parallel with the coil primary, so that it is held energized during most of each firing cycle but drops out when the points open. When the relay is energized, the capacitor charges from the mercury cell included in the tach and, when the relay drops out, the capacitor discharges through the meter.

Since the capacitor is charged by a mercury cell, which has excellent long-term voltage stability, the amount of energy stored in the capacitor is constant regardless of how often the relay operates (within limits, of course—but they are far outside normal operating range). Thus every time the relay drops out, a constant-energy kick is delivered to the meter movement.

The meter needle has a certain amount of inertia and so will take a definite time to fall back to zero. If the kicks of energy are received more rapidly than the needle can fall back, it will be held at some up-scale position. The exact position will depend upon the balance between the energy delivered by the kicks and the opposing energy of the meter springs; you can see that the more frequent the kicks, since energy per kick is constant, the farther up-scale the meter will read.

Actually, the meter is mechanically integrating the power content of the pulse train produced by the relay, and this power content is directly proportional to repetition rate of the pulse train. The result is a direct calibration in rpm.

The heart of this circuit is, of course, the relay. It must operate at relatively high frequencies yet have little or no contact bounce. Since the relay requirements are so stiff, a tachometer of this sort is relatively expensive. Price tags are in the $50 to $60 range.

For convenience in interchanging, the tachometers which use this circuit are physically divided into two sections. One, called the transmitter, contains all components except the meter itself and usually mounts as close as possible to the distributor, under the hood. The other, containing only the meter, is called the tachometer head and mounts in any convenient place near the driver.

The meters used in these tachs have conventional d'Arsonval movements, just like those used in v.o.m.'s and v.t.v.m's except that some have 200-degree scales rather than the 100-degree scales more common in electronic instruments. They usually have a front-adjustable "reference pointer" which can be set by the driver to remind him of the proper shift points and most include dial-light illumination bulbs.

The manufacturer declares that while the head of any specific model may be used with any transmitter of the same model, different transmitters in the series cannot be modified for use with different types of engines. The reason is that the accuracy of calibration can no longer be guaranteed. However, if facilities are available to re-calibrate, a 6-volt transmitter can be used with 12-volt ignition providing a dropping resistor of about 200 ohms is placed in series with the distributor lead from the tach transmitter.

Until the advent of the transistor, the relay-type tach circuit was the only one practical for accessory use. Vacuum-tube frequency meters and counters required too much plate and filament power to be of much interest.

However, the transistor and its low voltage requirements changed that, and a number of circuits have been developed in the past few years. The general approach is still that shown in Fig 1A, the major differences are in the "counter" circuits.

Knight-Kit | Lafayette | Dixson | Heathkit | Sparkomatic | Airguide

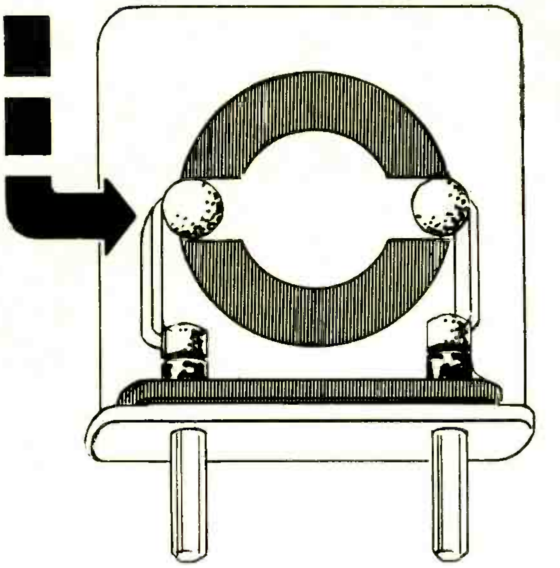
A grouping of typical automotive tachometers, all calibrated in engine rpm's.

Any type of circuit which produces standardized output pulses from the available input will be satisfactory as a counter. One of the earliest approaches was a circuit which passed the distributor pulses through a low-pass filter to remove any incidental noise, then used them to drive a transistor into saturation. The square waves resulting at this transistor's collector were limited in amplitude by a zener diode, differentiated in a capacitor-diode circuit to get sharp spike pulses, and amplified in a second transistor. The second transistor's collector current was metered to indicate rpm.

A simpler circuit, eliminating the second transistor, is shown in Fig. 2. This is the circuit of the negative-ground model of the "Knight-Kit" instrument, which measures up to 8000 rpm.

Input pulses from the distributor pass through a voltage divider, made up of $R1$ and $R2$, which serves the dual function of isolating the instrument from the spark portion of the ignition circuit and reducing the pulse amplitude (which may reach instantaneous values of 500 volts or more) to proportions suitable for the transistor circuitry.

Diode $D1$ removes the negative-going parts of the input pulse (which is actually a damped oscillation) and capacitor $C1$ smooths the pulse into a reverse saw-tooth waveshape. This waveform goes to the base of the transistor, biasing the transistor into saturation; resistor $R3$ limits base current during the high-amplitude (*Continued on page* 76)



UNDERSTANDING Frequency-control Crystals

By R. L. CONHAIM

There are many misunderstandings about quartz crystals, the main one being that they are always on frequency. A detailed analysis of crystals and their associated oscillators is covered in article.

ONE of the most common, yet least understood components of modern communications equipment is the frequency-determining quartz crystal. Deceptively simple in appearance, this remarkable device is responsible for the ability to maintain precise control of radio frequencies of transmitters and receivers in the crowded communications bands. Without this quality, frequency tolerances could not be met, with the result that thousands of users of radio communications would either be denied use of radio or forced to put up with constant interference from other stations.

That the crystal is grossly misunderstood is amply demonstrated by users, designers, and writers. Uninformed users, such as many Citizens Band operators, will interchange crystals among different circuits without realizing that this may affect the crystal frequency. Designers often make modifications in crystal oscillators, then appear befuddled by resulting changes in frequency. And writers often treat the "crystal oscillator" as though there were only one such named device, when in fact, there are many basic types, and hundreds of modifications of these.

Obviously, one article can't fully explore crystals as used in communications equipment, but perhaps such an article can clear up some of the misunderstandings and cover some of the basic considerations which affect communications users and those who service the equipment.

The Crystal

In communications equipment, the crystal is used in receiver and transmitter oscillators for the purpose of frequency control. It is also used in some equipment in the form of crystal filters to increase the selectivity of receivers but, for the purpose of this article, we'll confine ourselves to crystals as used in oscillators.

The quartz crystal is one of a number of substances that exhibit the piezoelectric effect. The word "piezo" is derived from Greek and means "pressure." Simply, the piezoelectric effect is the interaction between electrical voltage and mechanical stresses. Thus, a crystal can produce a voltage when subjected to certain mechanical stresses, or conversely, undergo mechanical stresses when subjected to a voltage. So, if we plug a quartz crystal into an oscillator designed for its use, the voltage present causes mechanical vibration at the particular frequency for which the crystal was designed.

In such use, the crystal is behaving like a tuned circuit and, in fact, can be represented as a tuned circuit as shown in Fig. 1A. Here we have the elements of capacitance, inductance, and resistance, represented by the symbols C, L, and R. In addition, we have the capacitance C_o, which represents the electrostatic capacitance between the crystal electrodes, when the crystal is not vibrating. The series C, L, and R, are sometimes referred to as the motional- or series-arm elements. Values of L are related to the physical mass of the crystal, those of C to the elasticity or flexibility of the crystal, and R to the heat-dissipating ability during vibration. As a tuned circuit, the crystal possesses an extremely high "Q"—as much as 30,000 to 100,000 or more when connected in the appropriate circuit.

Perhaps the most commonly misunderstood fact about a

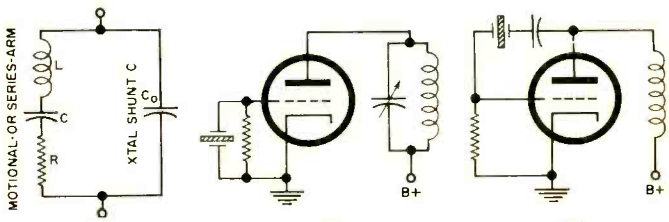
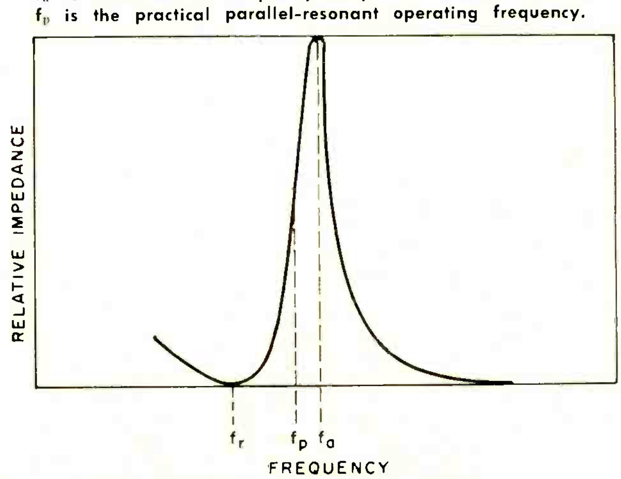


Fig. 1. (A) shows the equivalent circuit of a quartz crystal, (B) is a Miller oscillator, and (C) is a Pierce oscillator.

Fig. 2. The simplified impedance curve of a typical quartz crystal where f_r is resonant frequency at series resonance, f_a is anti-resonant frequency at parallel resonance, and f_p is the practical parallel-resonant operating frequency.



crystal is its ability to oscillate at different frequencies, depending upon circuit configuration and constants (See the impedance-frequency curve shown in Fig. 2).

Crystal Resonance

A crystal will normally operate at its series-resonant frequency, f_r and at higher frequencies up to its anti-resonant frequency f_a, depending upon the type of circuit in which it is an element. The difference between these two frequencies may be relatively small in normal terms, but when we consider the tolerances required in communications work, the differences are considerable. For example, a typical 10-mc. crystal may have a series-resonant frequency of 10 mc., and an anti-resonant frequency 16.9 kc. higher than 10 mc. The higher the frequency of operation, the greater the frequency spread between these two points.

As a matter of practicality, crystals are not operated at their true anti-resonant frequency, because with a tube circuit shunted across the crystal, there exists a condition where the entire circuit is relatively insensitive to small frequency changes resulting in instability at the region of anti-resonance. In practice, parallel-resonant circuits are operated at a frequency somewhat below anti-resonance, but the difference between this operating point and the series-resonant frequency is still considerable—typically, as much as 5 kc. or more for the 10-mc. crystal just discussed. Thus, rather than considering a crystal as a generator of a precise frequency, it is more accurate to consider it as a device that determines

Measured Frequency (in kc. at 32 pf.)	Measured Frequency (in kc. at 10 pf.)	Measured Frequency (in kc. at 50 pf.)
2000	2000.200	1999.950
3000	3000.600	2999.800
4000	4001.000	3999.700
7000	7003.300	6999.200
14,000	14,008.1	13,998.0

Source: International Crystal Company

Table 1. Relationship between operating frequency and the capacitance of the oscillator circuit in the equipment.

the limits within which the frequency may be varied. It is primarily the parameters of the external circuit in conjunction with the equivalent inductance, capacitance, and shunt capacitance of the crystal and its holder that fix the exact frequency of operation of a particular crystal.

Fundamental and Overtone Crystals

The fundamental frequency of a crystal may be considered as the lowest frequency at which the crystal will oscillate for normal modes of operation. Fundamental-type crystals are also used in harmonic oscillators in which the circuits are specifically designed for such operation. The harmonic frequencies are exact multiples of the fundamentals. For example, a 10-mc. fundamental crystal in a correctly designed oscillator may be made to produce a 20-mc. second harmonic, a 30-mc. third harmonic, and other multiples of the fundamental. Some oscillators are designed to produce many harmonics, although for communications purposes, the design of the oscillator is such that only the particular harmonic desired is produced in any strength.

By special processing, a crystal can be made to operate at what is known as an overtone frequency. The term "overtone" as applied to crystals is somewhat confusing, because it does not coincide with the definition as used in musical terms. In music, the first overtone is equivalent to the second harmonic of a fundamental tone. But in crystal parlance, the term overtone is used to designate a frequency approximately, but not exactly, the same as the equivalent-order harmonic.

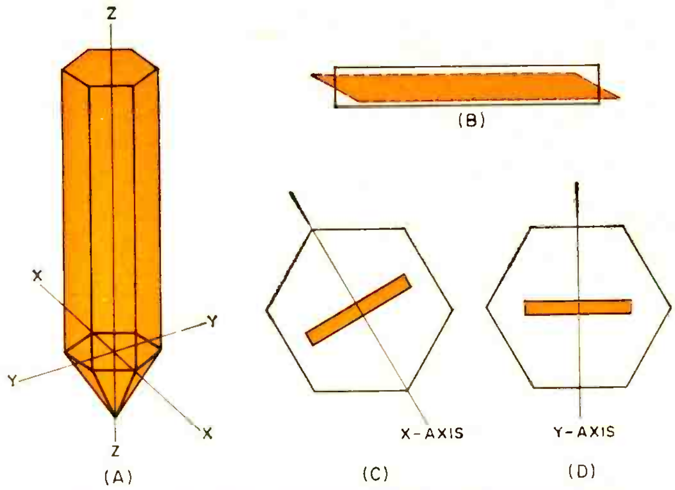


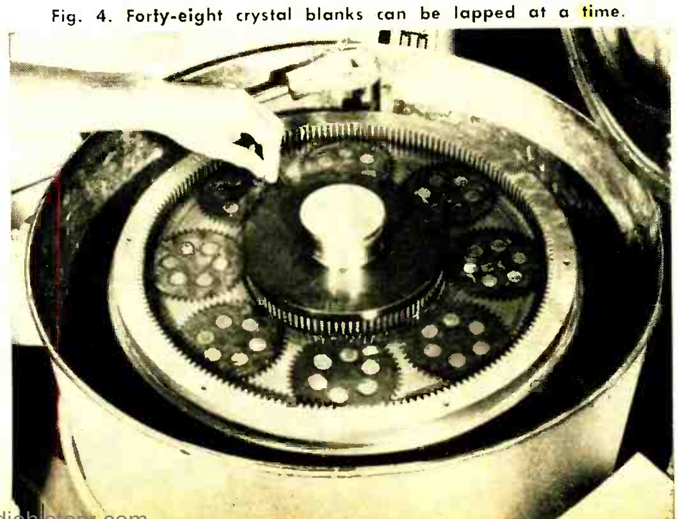
Fig. 3. Typical crystal geometry. (A) shows the axes of an uncut crystal, (B) is the thickness-shear mode of vibration, (C) is the orientation of an X-cut crystal, while (D) shows orientation of a Y-cut crystal. Other cuts are available.

Thus, the third overtone of a crystal is approximately, but not exactly, the same as the third harmonic. Such a crystal is ground for its exact overtone frequency, within specified tolerances, for the oscillator in which it is to be used, rather than being ground for fundamental frequency. The third, fifth, and seventh overtones are the most commonly used in communications work, and permit operation at higher frequencies than would be possible with a fundamental crystal. While the fundamental crystal could be multiplied by additional circuitry, the overtone crystal operates directly at the designated overtone in an oscillator circuit, without additional multipliers. It is important to note that an overtone crystal does have a fundamental frequency, and can operate at that fundamental frequency in a properly designed circuit, but the fundamental will not be an exact submultiple of the overtone. Some crystal testers, employing untuned oscillators, actually test overtone crystals in their fundamental mode but these tests are for activity rather than frequency.

Fundamental-type crystals are the preferred types in FM transmitters where both the carrier frequency and deviation can be multiplied simultaneously in subsequent multiplier circuits. Both fundamental and overtone crystals are used in aircraft transmitters, the overtone being preferred where simplicity of circuitry is desired. In such cases, the overtone is also multiplied, but requires less multiplication than would a fundamental-mode crystal. The overtone crystal is also widely used in Citizens Band transmitters and in receivers for most communications bands.

In most communications work, the parallel-resonant circuit is employed. In this circuit, the crystal is operating above its series-resonant frequency, f_r, and somewhat below its anti-resonant frequency, f_a. For such circuits, crystals must be

Fig. 4. Forty-eight crystal blanks can be lapped at a time.



ground for operation into a given external circuit capacitance. In most applications, this capacitance is nominally 32 pf. If the external circuit capacitance differs from that for which the crystal was ground, the frequency of operation will change, as shown in Table 1.

As can be seen from the table, the higher the frequency of operation, the more important becomes the factor of external circuit capacitance, and the greater the frequency error when circuit capacitance is not standard. If circuit capacitance is incorrect, there is a definite probability that the crystal cannot be brought to correct frequency by circuit adjustment, and may even cease to oscillate as the circuit is being adjusted.

The circuit shunt capacitance includes the internal capacitances of the tube, capacitors in the circuit, and wiring capacitance. The latter is especially troublesome in Citizens Band units which have been altered by the addition of crystal banks, not properly designed for the equipment. In such cases, crystals which operated within tolerance in the original circuit, may operate several kc. from desired center frequency when plugged into such "outrigger" crystal banks, due to the additional capacitance introduced by the wiring and location of most switchable multi-crystal banks.

Typical Circuits

Most communications equipment employ parallel-resonant types of crystal circuits. The two most popular types are the Miller circuit, shown in Fig. 1B and the Pierce circuit shown in Fig. 1C. The Miller circuit is basically the tuned-grid, tuned-plate type of oscillator, in which the tuned-grid circuit is replaced by the crystal. This circuit is usually used with overtone crystals, because the correct mode of operation can be assured by tuning the plate-resonant circuit. The Pierce circuit, which is basically a Colpitts oscillator, does not normally rely upon tuned elements in the circuit, other than the crystal. This is a distinct advantage in multi-channel equipment where only the crystal need be changed without the necessity of circuit tuning. However, should the crystal tend to oscillate in more than one mode, an undesired mode of higher activity may control the frequency of operation.

There are literally hundreds of variations of the basic Miller and Pierce circuits—so many, in fact, that it is often difficult to determine the basic type of circuit being used. One rule of thumb, which is not always accurate, is this: if one end of the crystal is at the same r.f. potential as the plate, or in some cases the screen, the circuit is probably a Pierce; if one end of the crystal is at the same r.f. potential as the cathode, it is probably a Miller.

Series-resonant circuits are sometimes employed, especially with fifth- and seventh-overtone crystals and in standards and measuring equipment, because of the excellent stability inherent in such circuits. However, these circuits are relatively complicated, often employing either multiple tube configurations or bridge circuitry. Typical series-resonant circuits include the Butler oscillator, capacitance-bridge oscillator, the Meacham bridge, and many others, some of which are quite complex. In all these circuits the crystal is designed to operate at series-resonance, in which crystal impedance is very low, and external circuit constants are of less importance in controlling the frequency of operation.

Crystal Cuts

The exact physical manner in which a crystal vibrates is dependent upon the way it is cut from the basic quartz as shown in Fig. 3A. Different vibration modes have different characteristics. In most communications work, the preferred mode of vibration is the "thickness shear" (Fig. 3B) in which the applied voltage tends to "shear" or distort the crystal along its thickness. The crystal blank is cut from the basic quartz according to the characteristics desired. A "mother" stone of quartz has three basic axes, designated *X*, *Y*, and *Z*. The *X* axis intercepts opposite angles of the six-sided-stone, as shown in Fig. 3C. The *Y* axis (Fig. 3D) intercepts opposite sides of the stone. The *Z* axis runs longitudinally through the stone. An *X*-cut crystal has its faces perpendicular to the *X* axis, while the *Y* cut faces are perpendicular to the *Y* axis.

In the early days of crystal usage, the *X* and *Y* cuts were the only ones used. But these types of cuts have certain disadvantages among which is their tendency to change frequency with changes in temperature. Modern communications equipment requires highly stable operation and to meet these requirements, new types of cuts were devised in which various angles of rotation of the plate around one, two, or even all three axes are employed. The most popular cut in communications is the *AT* cut. It may be oriented to give a zero-temperature coefficient (that is, no change in frequency) at any one of a number of different temperatures. Some are designed for room temperature operation and are adequate for base-station operation. Others are designed for use in crystal ovens maintained at some specific temperature such as 85°C or 75°C. These are used in mobile equipment where widely varying ambient temperatures can be expected. Others can be oriented to show a reasonable temperature characteristic over a fairly wide range of temperatures, and are used in aircraft equipment, Citizens Band transceivers, and similar equipment where frequency tolerance does not require the use of a constant-temperature oven.

Crystal Manufacture

Although the crystal is a relatively simple-appearing device, its manufacture requires a high degree of precision. Quartz is the basic material, although other substances have been used for oscillator applications. The raw quartz is silicon dioxide, a hard, glass-like, six-sided prism whose chief source of supply is Brazil. Quartz crystals as they exist in natural form are subject to many imperfections and structural faults and before a stone can be used for radio crystal manufacture, it must be examined for suita- (*Continued on page* 81)

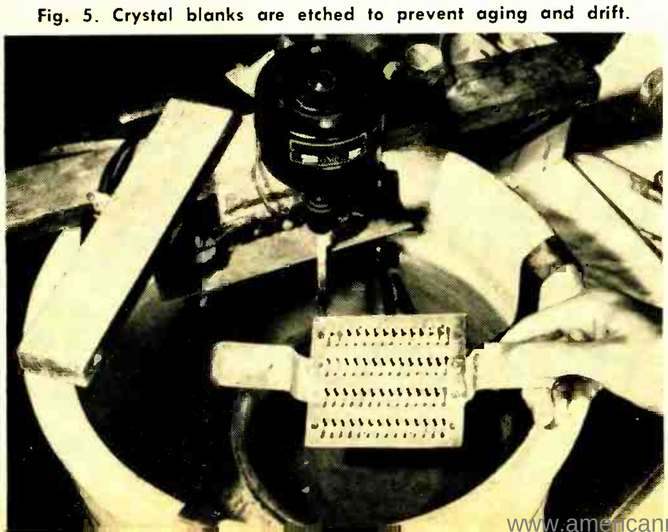
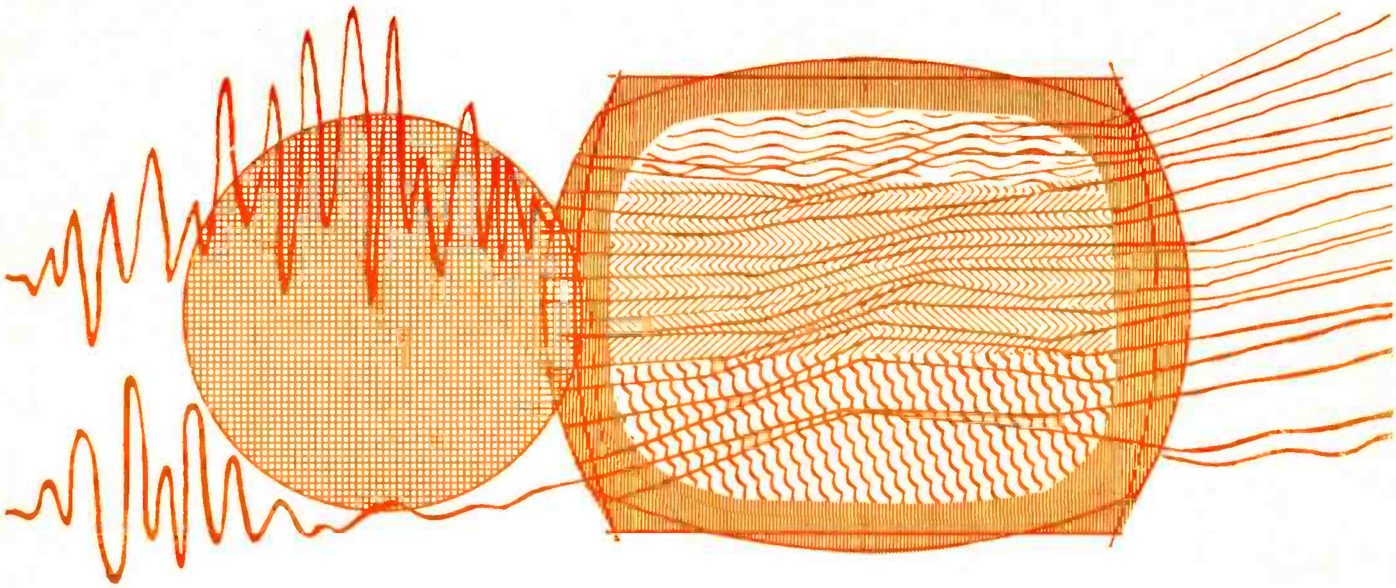


Fig. 5. Crystal blanks are etched to prevent aging and drift.

Fig. 6. Communications-type crystals are usually edge-clamped.



RADIO & TV INTERFERENCE: *Power-line Problems*

By THOMAS R. HASKETT & JACK D. BLOUNT

Part 1. *How to filter and shield electrical devices to eliminate interference, whether it occurs in institutions with large number of sets or in private homes.*

RADIO-frequency interference problems in the home are not too dissimilar to those encountered in large institutions such as hospitals, military barracks, correctional institutions, and school and college dormitories. The only difference is in degree. Certainly in large institutions because of the number of sets and electrical appliances in use, the problems are more severe.

There are four reasons for the problem: 1. Too many receivers too close together cause much mutual interference. 2. Many of the users prefer their hometown stations and, in many cases, these are usually quite distant and have weaker, noise-susceptible signals. 3. Most institutions house a large amount of industrial equipment which can produce considerable electrical noise. 4. Institutional regulations quite often prohibit certain electrical noise reduction remedies that can be taken in private homes.

Since interference handbooks are written to cover generalities, they usually do not deal with certain institutional problems. For example, they say little about mutual-receiver or TV-horizontal-sweep interference. Also, many of the handbook remedies, such as repositioning the receiver, may be prohibited by the institution.

Because r.f. becomes a noise problem only after it is both produced and received, this divides the remedies, and this article, into two parts. Part 1 will cover the elimination at the source while Part 2 will deal with noise at the receiver.

Man-Made Noise

Before looking elsewhere for noise, make certain that the receiver is not creating its own interference. Oscillation in an r.f.-i.f. circuit can often confuse the issue. In TV sets, Barkhausen radiation from the horizontal sweep section, picked up by the tuner, is a well-known example that should not be overlooked before trying to debug a noisy location. The types of self-generated troubles and their cures are adequately covered elsewhere and won't be rehashed here. Natural interference, such as static, will be handled under receiver treatment.

Many institutions had their electrical machinery and equipment installed with little thought to possible interference. Many such institutions are miniature cities with their own power plants, hospitals, and factories and these various services are often grouped close to living quarters. Hence, the noise level at the receivers can be very high. Also, the tenants can seldom move away from the noise.

Because r.f. noise may affect *any* receiver in the institution, once it has left its source, it is logical to begin the treatment at the source. These include: motors such as used in elevators, shavers, air conditioners, food machinery, etc.; non-motors such as fluorescents, neon tubing, r.f. generators; and thermostatic equipment, such as warmers, sterilizers, etc.; and the power distribution system itself—principally as a carrier, but also as a source of noise.

Grounding: Whatever the appliance, a low-impedance path to an r.f. ground is the first consideration. Since most power lines have one side grounded, some technicians think this does the job. It doesn't. In many cases it does not contact the motor frame or housing. Some systems use a third-wire ground, but this is only a *safety* ground—fine for the 60-cycle power line, but these lines often have a high-frequency impedance acting as an antenna for the r.f.

Both source and receiver should have a separate large diameter conductor directly to the earth. For a large motor, at least #10 wire, and preferably a wide copper strap, is best.

The usual cold-water pipe is not very good if it is any distance from the actual earth. It is much better to drive an

8-foot ground spike close by. One spike will do for a single appliance, but for a master system it is better to install several as the more spikes contact the earth, the lower the total resistance and the r.f. impedance. Spikes should be bonded together, preferably by brazing a large diameter wire—#10 at least—to the spikes. Several runs of this wire can then be made to various appliances. While a bit elaborate, this system removes interference by lowering the r.f. voltage to nearly zero.

If *every* piece, section, part, and wire of an appliance could be bonded together and directly connected to ground, there would be no r.f. noise generated. But you cannot directly connect both sides of the power line together—nor to ground, nor to many other leads in a machine, therefore filtering and shielding must be used to reduce the interference.

Filtering: A line filter, such as that shown in Fig. 1, when

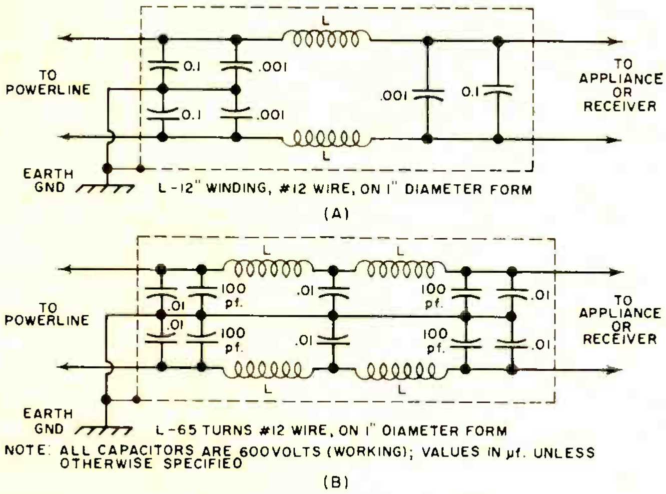


Fig. 1. Two types of r.f. filters that can be connected between the suspect noisy device and the local power source.

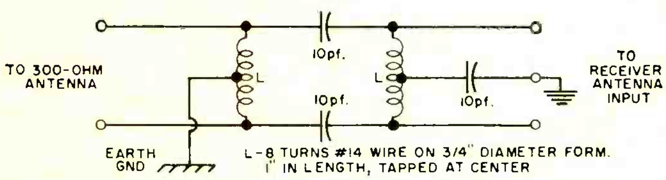


Fig. 2. TV high-pass filter helps reduce external interference.

properly installed in a shielded, grounded metal can, will usually keep noise off a power line. It is cheaper and more effective to use a separate filter at each appliance than to filter each receiver.

Whether you use commercial line filters or build your own, make sure the r.f. chokes and wiring will pass the current required by the appliance. These are low-pass filters having little effect on 60-cycle current but offering a high impedance to r.f. currents.

Filtering and grounding will remove r.f. *only* from the parts to which they are connected.

Shielding: A well-grounded metal enclosure will reduce to earth potential any r.f. radiated within it if it is electrically tight for that frequency. This is true for a simple grounded cage placed around an r.f.-noisy motor, or the elaborate shielding required for such deliberate r.f. generators as diathermy machines and r.f. heaters.

The low-power, random-frequency r.f. radiation produced by fluorescent lights, noisy motors, and intermittent-contact devices such as thermostats and relays is simple to shield. A single layer of copper screen, bonded at all seams and well grounded, will remove r.f. as a *radiation* problem. Filter the lines to eliminate such random-frequency radiation as a conduction/re-radiation system problem.

Where shielding exists, make certain all shields and the housings have good electrical contact with the frame and ground lead. Remove paint along seams and be sure metal bites into metal. Replace all broken or missing lock washers which mount parts as these often make the electrical and r.f. bond as well as securing the parts mechanically.

The effectiveness of these three treatments depends on the quality of the grounding. Large size wire, short, direct runs, and low-contact resistance are the keys to success.

Motors

A large institution will have hundreds of devices using motors. Here, noise is caused by dirt, misadjustment, sparking at the commutator brushes, and electrical defects—such as one coil open/shorted or a missing ground.

Clean the motor, adjust or replace the brushes—checking for *kind* as well as fit, and you'll reduce the noise. Rarely will shielding be required.

Many mechanics, unknowingly, have often created an r.f. noise source by remounting a motor to cure vibration. If the motor is no longer grounded to the frame of the machine, bond the motor and frame together with an automotive battery or ground cable. Use one long enough to permit the rubber snubbers to remove the mechanical vibration.

Non-Motors

In addition to the power line and deliberate r.f. generators, non-motors are largely contact devices such as thermostat-controlled units, relays, fluorescent lights, and occasionally neon tubing. All shielding, cabinets, and conduit must be electrically bonded and well grounded to generate the least noise. All wiring must be electrically tight.

Fluorescent lights should be in grounded metal channels, a point often neglected by budget-sensitive institutions. Low-power-factor (15%) ballasts can produce 10 times the noise of a high-power-factor (90%) ballast, and the 15% ballast always become noisy. To permanently remove noise, only the ballast need be changed.

Check starters by substitution, removing any remaining noise by placing a .05-µf. capacitor across the supply as the simplest line filter. Any additional filtering, such as Fig. 1, must be placed in a metal box bonded to the lamp enclosure. Re-radiation can take place if the enclosure is not grounded. Screening or special conductive glass may be used in very sensitive locations. Such shields must be grounded.

Power Line

This very common source of trouble can act as a carrier for the noise generated in devices connected to it. Filtering each device will remove that noise but, unfortunately, this is not a complete answer. In older buildings, wiring with corroded and poorly installed fittings is a real noise generator. Sometimes these fittings partially rectify the a.c. to produce a d.c. bias on the line. Also, they may arc, thus generating their own brand of noise. Locate such faults by unplugging and sectionalizing, correcting the defects as they are found.

Don't forget that "power line" includes everything from the receiver back to the pole transformer on the street or a generator in the institution's internal power plant.

When telephone or audio lines are placed too close to power lines, electrical noise is picked up and widely distributed.

It is not unusual to find a line with only 85 or 90 volts across it, sometimes so overloaded the insulation is cooked. This is a fire hazard and a danger to life as well as an interference source. A new, heavier line should be installed.

Deliberate R.F. Generators

Hospitals and other institutions use equipment such as r.f. heaters, mercury-vapor lamps, x-rays, diathermy, and other devices. All purposely generate r.f., but for *non*-communications uses. The amplitude is often high (an x-ray may operate at 150 kv. or more), making them perfect jammers should all efforts at shielding fail. Many institutions have several such potential jammers.

Commercial equipment is usually well shielded and filtered, except that here you are dealing with r.f. *power* which means complete shielding, complete filtering, and the entire system well grounded. Beware of painted sheet-metal housings, poor metal-to-metal contact, and often no grounds which makes them antennas for r.f. rather than shields. Panels of the housing shield should be joined by screws not more than three inches apart and these should make good electrical contact to the frame.

Line filtering is a waste if poor r.f. shielding lets noise leak around the filter into the line on the supply side. Like motors, the *whole* assembly must be r.f.-grounded with the shortest and heaviest copper conductor to a good earth contact.

In these r.f. generators, close all openings larger than ⅛" with copper screen or sheet, bonding all contacts. Make a positive bond to chassis of every conductor (or its filter) at the point of entry to the machine.

A shielded power line may be needed to prevent r.f. coupling around the line filter, grounding the shield at the entrance.

Any kind of r.f. transmitted near or within an institution can cause interference in three ways: architectural harmonics, electronic harmonics, or cross-modulation. It makes *no* difference what kind of r.f.—radio, TV, CB transmitter, or a diathermy machine—if close, and of high enough power, it will create an interference problem.

Architectural Harmonics

Acting like a defective power line, poor or corroded joints in building parts will create harmonics. Gutters, piping, downspouts, and ducting are examples. Corrosion in metal-to-metal joints causes them to act like the crystal-diode mixer in u.h.f. TV, producing beat frequencies and re-radiating them. As these harmonics are not the fault of the transmitting station, it is not their job to get rid of them. With a portable radio and much patience, you can track down these trouble spots. Listen for a strong broadcast station at twice its normal frequency—say 680 kc. heard at 1360 kc. Once located, each joint must be completely opened, or bonded together, and, where possible, grounded.

Electronic Harmonics

When strong r.f. gets into battery chargers, power supplies, audio amplifiers, and the like, the r.f. is rectified and can produce harmonics. The strength of the re-radiated harmonic (and your troubles) decrease as the frequency increases, unless nearby metallic objects act as resonant antennas, strengthening particular harmonics.

The solution is again to treat them as noise sources—ground, filter, or shield each one. Also, some lighting fixtures may need to be grounded to prevent this resonant re-radiation.

Since cross-modulation occurs within receivers, it will be treated in Part 2 of this series.

Self-Generated Interference

Seldom a problem in private homes because of the fewer receivers and greater spacing, self-generated interference is a common problem in institutions. It is not unusual to find several radios within 10 feet of a TV set whose sweep will often tear up AM reception, particularly those desired out-of-town stations with their weaker signals.

The fundamental frequency of the horizontal sweep is 15.75 kc. But, due to the high voltages, high power level, and nearly square waveform, it is extremely rich in harmonics—which are located every 15.75 kc. through the AM band. In the AM receiver, the local oscillator will beat with these harmonics as well as the signal of the desired station. If the resultant beat is within the i.f. passband, the resulting two i.f. signals will beat again in the second detector, producing a fixed-frequency squeal.

It is not surprising that many TV sets are AM jammers, since efficient shielding is expensive and would be unnecessary in an average home. New TV receivers are required to limit their power-line radiation, but often radiate into free space. Here, you have to remove the fundamental and the associated harmonics. Treatment consists of filtering and shielding, grounding as completely as you can. Ground the chassis separate from the a.c. ground if possible. With an a.c.-d.c. set, and any set using an autotransformer for power, use a series capacitor (.01 μf., 600 volts) since the chassis can be at line potential.

Install an a.c. line filter, similar to that shown in Fig. 1, at the chassis apron, using a shielded power cable to prevent radiation around the filter. To prevent antenna radiation, a high-pass filter in a shielded can must be used—even for a rabbit-ears antenna. Commercial types are available, or you can construct one as shown in Fig. 2. Do not omit the earth ground. This filter suppresses the sweep-circuit radiation and also prevents the TV set from picking up many undesired signals.

If, after grounding and filtering, shielding is necessary, it must be done with care. Completely shield the inside wall of the cabinet using foil or copper screening tied to the chassis at the set ground connection. A shielded high-voltage CRT anode lead should be used. As yoke spikes are high, put about 10 kv. of plastic insulation between the yoke and the grounded foil you wrap around it. Break the foil continuity (insulate) so as not to make a shorted turn around the yoke, or it will decrease raster size.

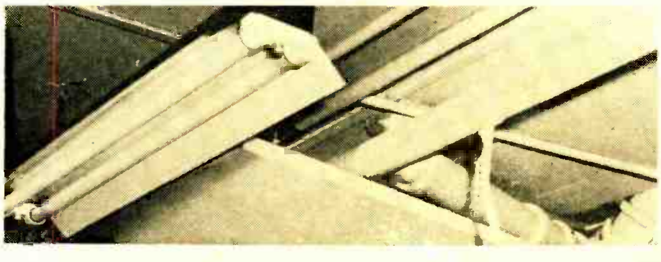
Sometimes, although very rarely, r.f. radiation through the face of the CRT can exist. In this extreme case, install a leaded safety glass which is then grounded.

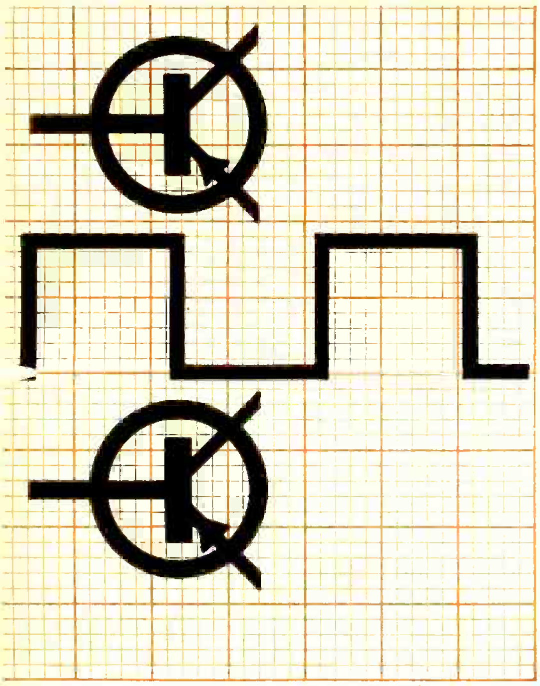
Still other remedies are possible, but they are applied to the disturbed receiver and will be taken up in Part 2.

(Concluded Next Month)

Another example of faulty power-line installation where telephone or audio lines are not shielded from the power lines.

Fluorescent fixtures like this can produce electrical noise if they have faulty components and are not shielded properly.





NEW HIGH-QUALITY TRANSISTOR AMPLIFIER

By FRED L. MERGNER
Director of Engineering, Fisher Radio Corp.

Design features and circuit operation of Fisher's new solid-state integrated stereo amplifier. Also a discussion of safety features and service techniques.

THE only justification for introducing high-fidelity equipment with new and greatly different design concepts is to improve performance. While styling, operating convenience, and other factors play an important part in component design and consumer acceptance, a transition as great as from tubes to transistors in amplifiers must be accompanied by all realizable performance improvements.

Differences among amplifiers are not merely subjective matters. Although present-day amplifiers have reached an unprecedented degree of technical perfection, differences among them still exist and can be discovered in the quantitative results of performance tests. In addition, listening tests, in which the same speaker is switched from the output of one amplifier to the other, will also help to reveal differences among several units. By performing both types of tests and using a wide variety of program material for testing, we are convinced that, when properly designed, both transistor and tube amplifiers are capable of supplying excellent and virtually equal tone quality.

There is, however, one important difference: in order to achieve the same high over-all performance now available from a transistor amplifier, its tube counterpart requires a much larger package, a higher power output, and very large, complex output transformers. A transistor amplifier, however, can be built without these complications and provides, in addition, the following desirable performance extras: 1. Increased long-term stability and therefore much greater life expectancy. 2. Virtual elimination of changes in performance with aging. 3. Reduced size for a new degree of freedom in styling. 4. Reduced power-supply requirements, resulting from elimination of the need for filament power, and increased amplifier efficiency.

Considering these facts, and using the possibilities inherent in transistors to their full extent, we have designed an integrated control-amplifier, Model TX-300.

The Output Stage

The high-current, low-voltage capabilities of power transistors suggest the possibility of eliminating the output transformer, which is usually required in tube amplifiers as a coupling element between output stage and speaker. Assuming an otherwise satisfactory design, the only limitation inherent in this approach is the absence of multiple-impedance output taps. Matching the amplifier output to speakers with impedances between 4 and 16 ohms can be maintained to ensure practically equal power output within this impedance range, by providing a certain minimum internal impedance of the output stage and power supply. This technique enabled us to eliminate the output transformer, with all its inherent design limitations. The major advantages of this design approach, which were covered in detail in the January 1964 issue of this magazine, are extremely wide power bandwidth (limited, basically, only by the characteristics of the output transistors) and high operational stability with large amounts of negative feedback.

After the decision had been made in favor of an output-transformerless design, we then considered the amount of power required to adequately drive existing speaker systems. From our long experience with tube amplifiers, it was apparent that a minimum of 25 watts per channel, and possibly more, was desirable to permit high volume levels with low-efficiency speaker systems.

The next step was to find a transistor which could deliver this power *throughout* the audio spectrum while operating well *below* its maximum rated capabilities. Alloy-junction transistors suitable for application in high-power amplifiers have been available for several years. They were discarded, however, because of limited power bandwidth resulting from their poor high-frequency performance. Their cut-off frequency is normally not higher than 8 kc. (where gain is 3 db down).

Silicon transistors appeared to be an attractive alternative since they can generally be operated at higher junction temperatures than germanium types and therefore offer a wider margin of safety at higher temperatures. However, this type of transistor has only fair high-frequency performance and very low gain which limits the amount of feedback which can be applied. Since superior high-frequency response was our prime consideration, the higher operating temperature became of secondary importance, and a third type was finally selected.

At the present time, this goal can be achieved only with high-gain germanium drift-field transistors which have a gain-bandwidth product of 4 to 5 mc. With this type, however, careful attention must be paid to a phenomenon called "secondary breakdown" which is inherent in these devices. As explained in the previous article, high-frequency tone bursts of sufficient amplitude can cause a funneling effect which concentrates current flow through a small portion of the junction and ultimately punctures it. To avoid this breakdown problem, it was necessary to limit the operating voltages of each transistor to 50% or less of the maximum allowable collector-emitter voltage. By dividing the operating voltages required for a given amount of power over *four* junctions instead of the conventional two, an unusually high margin of safety was achieved. The output circuit which resulted will be described later since it affects more than one facet of amplifier performance. A further bonus with this design approach is the possibility of distributing the heat generated in the output transistors over a larger *number* of junctions (hence a larger heat sink area), resulting in lower, and therefore safer, operating temperatures.

After the decision had been made in favor of germanium drift-field transistors, the choice of their operating conditions (between class A and B) was fairly obvious. Class-B operation was selected because it offers distinct advantages with transistors. Maximum theoretical efficiency for a given dissipation is approximately 70%, as opposed to 50% for class A. In addition, continued operation of the transistors at elevated junction temperatures, as is the case in class A at *medium* power-output levels, would detract noticeably from device life expectancy.

Output stages biased for class-B operation draw only small amounts of current under quiescent conditions. The magnitude of this current (set by potentiometers $R1$ and $R2$ in Fig. 2) is selected with two contradictory design goals in mind. First, it should be as low as possible, to reduce the average junction dissipation. On the other hand, it must be set high enough to permit class-A operation of the output stage at *low* power levels. This is necessary to eliminate crossover distortion, which would result from complete current cut-off during non-conducting alternations in class-B operation. As power output increases, a gradual transition of the operating mode from class A to class B takes place, permitting the desired high efficiency when large amounts of power are required.

The four transistors required in each output stage to supply the predetermined power output with a greater safety factor can best be arranged in a single-ended, series-connected push-pull configuration. This circuit is basically a single-ended push-pull amplifier where the two transistors in each half are connected in series and biased for large-signal operation. In the circuit of Fig. 2, transistors $Q1$ and $Q2$ are operating in a common-emitter mode, driven from the secondaries of transformer T. Transistors $Q3$ and $Q4$, operating as common-base amplifiers, are driven by the varying voltages appearing across the high impedance of the $Q1$ and $Q2$ collectors.

As compared to a regular parallel push-pull or bridge-type circuit, this array has several advantages. In a bridge or parallel configuration, the amount of power available is limited to twice the power from a pair of transistors. In the circuit shown in Fig. 2, however, transistors $Q3$ and $Q4$ can deliver more than half the total power, resulting in higher total power output.

The junctions of transistors $Q1$ and $Q3$ as well as $Q2$ and $Q4$ are connected in series, thus permitting higher supply voltages than bridge or parallel circuits. In addition, the breakdown of $Q3$ and $Q4$ is governed by the maximum collector-to-base voltage with the emitter open (V_{CBO}). Therefore, a higher-voltage, lower-current power supply can be used, which has generally better regulation, because reduced current requirements reduce the voltage drop due to internal resistance.

The basic operation of a single-ended push-pull circuit, often referred to as a "totem-pole" circuit, can best be seen by referring to the equivalent circuit illustrated in Fig. 1. The circuit shown here is simplified by replacing the two transistors used in each half of the output stage with a single transistor.

The graphs in Fig. 3 show one and one-half cycles of the audio drive voltages $V1$ and $V2$, of collector-emitter voltages V_{CE1} and V_{CE2}, and collector currents I_{C1} and I_{C2}. The out-of-phase audio signals $V1$ and $V2$ present at each base will alternately drive the corresponding amplified collector currents through load R_L, representing the speaker.

From the graphs for I_{C1} and I_{C2}, it can be seen that even in the non-conducting half-cycle a small amount of current (I_{CO}) will be flowing, depending upon the bias supplied by $R1$, $R2$ and $R3$, $R4$, respectively. As explained, this idling current of 50 ma. minimizes crossover distortion at low power levels. The voltage V_M is exactly midway between the negative and positive outputs of the power supply. When the bias adjustments are properly made, the voltage at this point is zero with respect to ground.

The maximum continuous power available from the circuit shown in Fig. 1 is a function of the supply voltage (V_S), the collector-emitter saturation voltage of the transistors used ($V_{CE\,sat}$), the emitter resistor (R_E), the reactance (X_C) of the coupling capacitor (if used) at the test frequency, and the load resistor (R_L).

This can be expressed as:

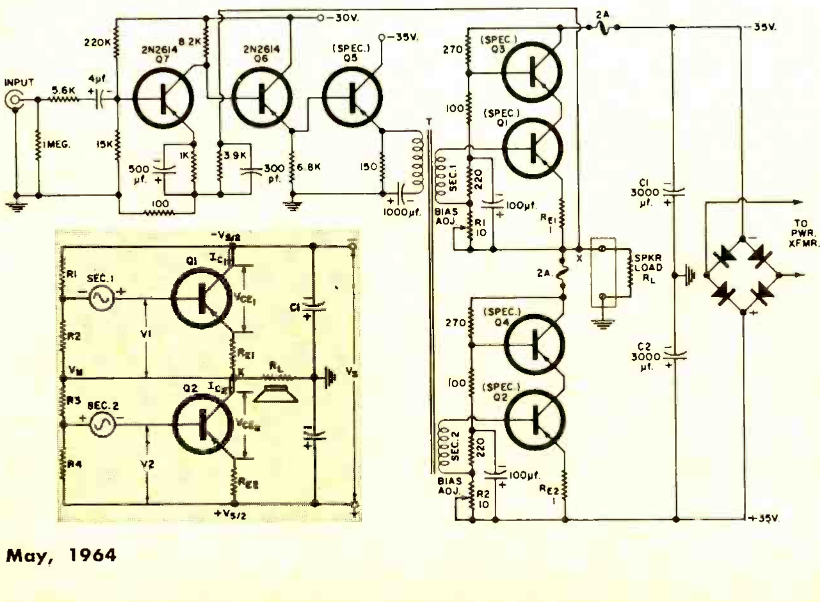
$$P_{out} = R_L \left(0.707 \frac{0.5V_S - V_{CE\,sat}}{R_E + \sqrt{R_L{}^2 - X_C{}^2}} \right)^2$$

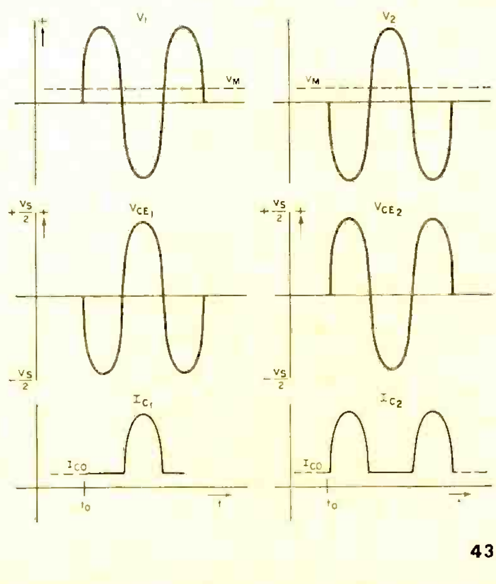
Isolation of the speaker from d.c. potentials of the output stage can be approached in two general ways. In case the power take-off point "X" (see Figs. 1 and 2) carries a d.c. potential with regard to ground, an electrolytic coupling capacitor must be inserted. It should be large enough to present a negligible impedance at low audio frequencies, in order to prevent a reduction in available output power at these frequencies. However, even with a large capacitor, the phase shift at the junction formed by capacitor and speaker load

Fig. 1. (Lower left) Each pair of output transistors employed has been replaced by a single unit in the equivalent circuit.

Fig. 2. (Center) A somewhat simplified schematic diagram of one channel. The preamplifier stages have been omitted.

Fig. 3. (Right) The various operating waveforms that exist in the equivalent output circuit illustrated in Figure 1.





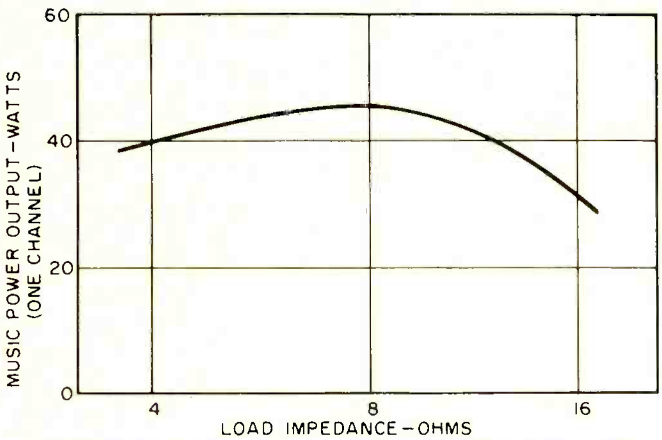


Fig. 4. Variation of music power with load, at 1 kc., 0.5% THD.

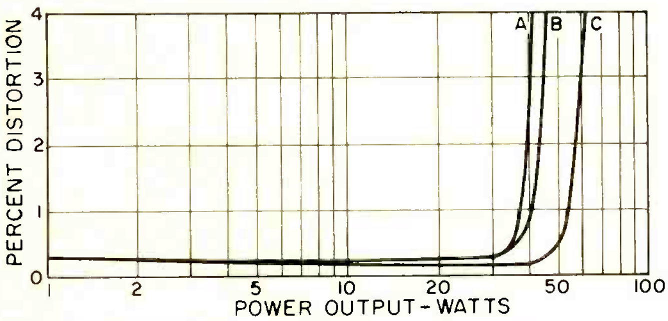


Fig. 5. Distortion for one channel. (A) is IM distortion using 60 cps and 7 kc. in 4:1 ratio. (B) is THD (total harmonic distortion) at 1 kc. (C) is THD at 1 kc. vs IHF music power.

(*i.e.*, the point at which feedback is obtained) would be enough at very low audio frequencies to produce a tendency toward instability within the amplifier.

To avoid these problems, a direct-coupled circuit was devised which functions through the use of a center-tapped, full-wave bridge power supply. In this case, point "X" has zero potential with respect to ground. This requires two large, separate electrolytic filter capacitors, but the end result is a very low ripple content, due to the balanced nature of the amplifier's power supply.

The Driver Stage

Two basic possibilities exist for driving the output stage: by d.c. coupling or by a.c. coupling, using a driver transformer. At first glance the elimination of this transformer in a d.c. coupled circuit seems to be very attractive and promising. There are, however, several disadvantages to this approach.

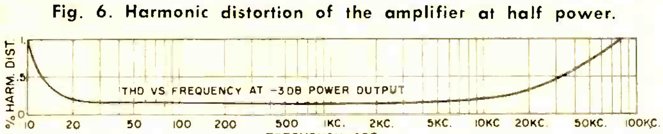
The importance of providing a low d.c. resistance between base and emitter of transistors in the output stage cannot be overemphasized. The two driver-transformer secondaries plus the bias potentiometers, represent the required low d.c. resistance path (approximately 7 ohms) in the base-emitter circuits of the output transistors.

The stability factor, S, of the circuit shown in Fig. 1 can be expressed as follows:

$$S = \frac{\frac{R1 \times R2}{R1 + R2} + R_{s1}}{R_{E1}}$$

where R_{s1} is the d.c. resistance of a secondary winding. The extremely good d.c. stability factor of the unit makes it possible for this amplifier to operate continuously under the most unfavorable conditions without going into thermal runaway. It is quite unlikely that such stability could have been achieved economically without the use of a driver transformer. These are already reasons enough to strongly suggest its use. There are, however, other compelling reasons.

Fig. 6. Harmonic distortion of the amplifier at half power.



The driver transformer interrupts the d.c. path between driver and output stages. This makes it impossible for the d.c. voltage conditions of the output stage to be affected in the event of transistor failure in the driver or pre-driver stages, thus preventing base-emitter breakdown and consequent destruction of the four costly output transistors. In direct-coupled circuits, the type of chain-reaction destruction described is a distinct possibility.

When driven from a cascaded emitter-follower (as is the case here), the transformer presents, in addition, an impedance of less than 15 ohms to the output transistors, assuring an excellent transfer characteristic. This is evidenced by the low distortion of the amplifier without excessive amounts of negative feedback. This low source impedance and the use of drift-field transistors is the main reason that the IHF power bandwidth extends to the unusually high frequency of 70,000 cps.

To take full advantage of these favorable properties achieved through the use of a driver transformer, careful attention must be given to its electrical design. Its bandwidth should be wide enough to avoid any effect on the frequency and phase response of the over-all output circuit, even when large amounts of loop feedback are applied.

By using tri-filar windings, virtually perfect coupling is achieved between the primary and the two secondaries, resulting in an over-all bandwidth (at −1 db) of 5 to 800,000 cycles. Since only ½ watt is required to drive each of the output stages, this transformer can be made quite small, without affecting its characteristics.

Pre-Driver Stages

The driver transistor Q5, operating in the common-collector mode, is driven by a high-gain *p-n-p* transistor, Q6, connected in a Darlington configuration. This ensures both high input and low output impedances. An identical *p-n-p* transistor, Q7, which has a 10-mc. gain-bandwidth product, precedes these two stages and is also d.c.-connected to avoid phase shift at low audio frequencies. The over-all feedback voltage is derived from point "X" and returned to the emitter of the first pre-driver transistor. Because of the very wide bandwidth and negligible phase shift of the driver transformer and of the output, driver, and pre-driver stages, only minor frequency correction was required.

The low-impedance power supply for the output stage uses four high-current silicon diodes in a bridge configuration, supplying equal voltages of positive and negative polarity with respect to ground.

It is conservatively designed, as can be inferred from the continuous power output capabilities (both channels driven) of the amplifier at low frequencies.

A separate full-wave supply (not shown) provides the −30 volts for driver and pre-driver stages. This results in high stability and provides isolation from the output stage, whose supply voltages vary somewhat with changes in power output. The remaining tone-control and preamplifier stages obtain their negative voltages from a capacity-multiplier transistorized filter section. The effective time-constant of this filtering network is more than two seconds, avoiding high-powered "plops" due to slow turn-on of the preamplifier and tone-control stages of the amplifier.

Performance

The Model TX-300 control-amplifier is designed to operate into resistive, capacitive, or mixed loads of from 4 to 16 ohms, thus enabling it to drive all widely used speaker systems. Fig.

4 shows the slight variation of available output music power with load impedance.

In more conventional circuits, the internal impedance of the output stage plus that of the power supply is lower than the lowest rated load impedance. These stages must, therefore, be designed to restrict the collector current flow and consequently the heat dissipation in the transistor junctions, to values well below maximum permissible ratings. In this amplifier the restricting elements are four series-connected transistor junctions per output stage, the relatively large emitter resistors (1 ohm each), and the power supply with special characteristics. When speaker impedances exceed 16 ohms, the increasing load resistance R_L naturally imposes a limit on the available output power at a fixed supply voltage. Both these factors act to prevent damage due to accidentally shorted or open speaker terminals.

Fig. 5 shows the available power *versus* total harmonic distortion (THD) at 1 kc. with either one or both channels driven, as well as the available music power, measured according to IHF standards. The graph also contains a curve indicating IM distortion *versus* output power, which closely follows the curves for the harmonic distortion and remains practically level up to full rated power. This is in contrast to tube amplifiers where the IM distortion increases with increasing output power.

Perhaps the best evaluation of the unit's low over-all distortion is given by the IHF power bandwidth curve of Fig. 6. This curve can be plotted in two different ways. First, available power *versus* frequency may be plotted at a fixed distortion level (1% THD, for instance), or the distortion level for a fixed power level at various frequencies may be shown. We feel that the latter approach is more meaningful since a speaker requires a roughly constant input power level for a given sound output, regardless of the resultant (and perhaps increasing) distortion at both extremes of the audible spectrum. For this reason, we prefer to indicate the distortion at a constant power output, corresponding to the level established by the IHF standards. This curve is indicative of the unusually wide frequency range (10 to over 70,000 cps) through which this power is available at less than 1% distortion. Within the important audible band, the distortion drops to less than 0.3%.

Since production units were not available at the time of writing, the figures and data in this article are based upon a number of engineering "evaluation samples." The measurements given represent the average of several units.

The damping factor at 20, 1000, and 10,000 cps and for the three standard speaker impedances is given in Table 1. Due to the inherent d.c. resistance of the speaker voice coil (generally 80% of its rated impedance) a damping factor of five can be considered sufficient, and higher values do not contribute materially to better speaker damping. The amplifier's square-wave response (Fig. 7) at 20 cps, 1 kc., and 10 kc. is indicative of its good transient response. The low tilt of the 20-cps square wave is a result of the power amplifier's extended low-frequency response characteristics.

FREQUENCY	IMPEDANCE		
	4Ω	8Ω	16Ω
20 CPS	6	10	32
1000 CPS	6	10	32
10,000 CPS	5	7	25

Table 1. Damping factor at various frequencies, impedances.

Safety Features & Servicing

In spite of its excellent performance, a transistor amplifier such as the TX-300 would be of dubious value if it did not possess at least the same reliability and service life we have come to expect from tube amplifiers.

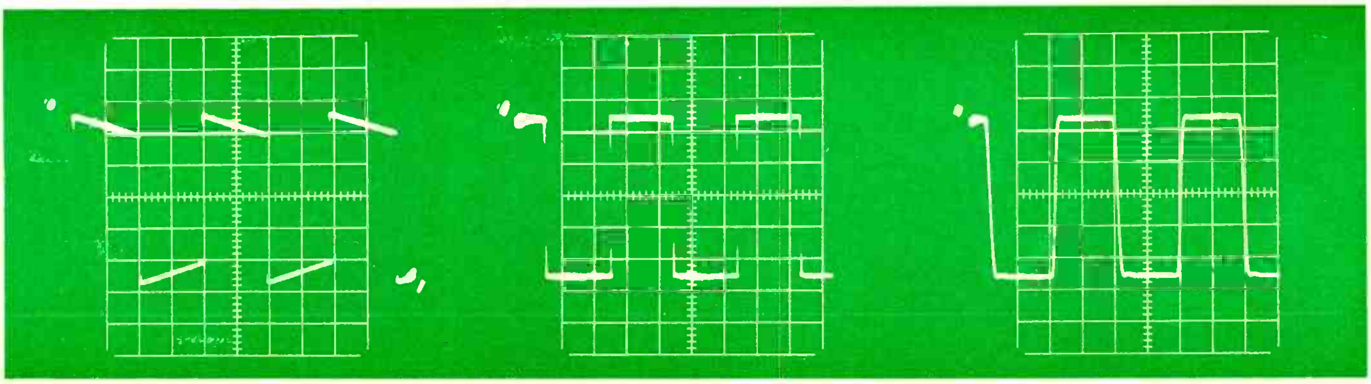
Experience with late-type transistors, accumulated over several years, provides evidence of the extended life span of transistors. In addition, the considerably lower operating temperatures of transistor equipment further contribute to long operating life. To fully realize this performance, every component used in the development of the amplifier underwent extensive and comprehensive life- and performance-testing.

The amplifier has been tested for extended periods under conditions several times as severe as those encountered in actual use. With a power-line voltage of 135, an ambient temperature of 140 degrees F, and with low-frequency square-wave input set to produce 40% of rated power with a 4-ohm load, the amplifier was found to be thermally and electrically stable. Furthermore, it does not require an "on-off" duty cycle for testing with sine-wave signals.

One fuse in the power transformer primary and two in each channel protect the output transistors if the output terminals or the speaker voice coils are shorted accidentally. In addition, the fuses protect the speakers from d.c. overload in the event of output transistor failure.

A word of caution about testing transistors is in order here. While the service technician may use most of his present test equipment, he should be sure that there are no leakage paths to the line since line voltage applied across two terminals of a transistor could cause transistor breakdown. Ohmmeters should not be used to test transistors since their test voltage may exceed the transistor's base-emitter breakdown voltage and thus destroy the transistor. Instead, we recommend that a high-quality transistor tester be used. (*If the characteristics of the ohmmeter are known accurately, such as the maximum voltage and current on the various ranges, and if these do not exceed the ratings of the* (*Continued on page* 77)

Fig. 7. Square-wave performance of the amplifier at 20 cps (left), 1 kc. (center), and at 10,000 cps (right).



NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

A description of a new single-sideband transceiver and a selective-call unit that does not use resonant-reed relay.

TWO new CB devices, one of which is in the sideband category, are described this month. The first unit is a new transceiver by *Mark Products*. It carries the evolution of CB sideband full circle—as the first commercial CB rig to feature single-sideband circuitry. The second circuit reveals how one manufacturer, *Polytronics*, has designed a selective tone-call adapter without employing the usual resonant-reed type of relay.

(a) Mark "Sidewinder" SSB-27 Transceiver

The development of sideband transmission for CB radio has not only been rapid, but remarkably varied. In little more than a year, all basic sideband techniques have appeared in commercial CB equipment. Most recent is the *Mark*[1] "Sidewinder" SSB-27 transceiver. Utilizing *single*-sideband, it represents the most sophisticated sideband system for AM communications. Until now, CB sideband could be split into two types, both in the double-sideband category. There is double-sideband *reduced* carrier; steady r.f. carrier is partially reduced in amplitude, with the subtracted energy injected into two sidebands for more "talk power." Its twin attractions are low cost and compatibility (enough carrier is transmitted for any receiver to properly detect the signal). Second, there is double-sideband *suppressed* carrier. Reduction of the carrier is maximum. The two sidebands receive even more of a boost, but a conventional receiver requires a beat-frequency oscillator for detection.

In the single-sideband system of the "Sidewinder," both one sideband and the carrier are suppressed. Just one sideband is transmitted—and its energy content now consists of power normally expended in the carrier and the alternate sideband. The circuit not only makes the most efficient utilization of modulated r.f., but permits a new-to-CB mode of operation, termed "split-channel" by the manufacturer. It is possible for two different stations to simultaneously operate on the same channel; one on upper sideband, the other on lower, as detailed later. (The term "split-channel" is also applied to FM equipment operating in other two-way services. An FCC ruling reduced FM deviation, and thus bandwidth, in order to accommodate more stations. Single-sideband in an AM system produces a comparable effect.)

The block diagram of Fig. 1 shows major sections of the "Sidewinder" transceiver. Consider, first, the transmitter. It initially creates a double-sideband signal, removes one sideband through filtering, then heterodynes an SSB signal up to 27 mc. (Heterodyning is required since raising frequency by conventional multipliers would destroy audio in the sideband.) A starting point for transmit is at *V13A*, a microphone amplifier. Audio is fed to phase inverter *V3B* to provide push-pull audio output. Next is balanced modulator *V2*. This is new to CB circuitry. It is a 6JH8 sheet-beam tube developed for demodulation in color TV, but widely applied in SSB equipment because of its ability to suppress an input carrier to extremely low levels. Push-pull audio and steady r.f. are combined to produce a double-sideband signal and canceled carrier. The r.f. needed for the production of sidebands is supplied by the 7.5-mc. crystal oscillator *V1*.

If audio is assumed to be 1 kc., frequencies from the balanced modulator are: 7.501 mc. for upper sideband and 7.499 mc. for lower, with 7.5 mc. suppressed. Next step is the removal of one sideband. Note that balanced modulator *V2* feeds the crystal filter through a cathode-follower (which matches the high tube impedance to the low filter impedance). The narrow 3-kc. slot of the crystal filter admits only the upper sideband, 7.501 mc. in our example. A single-sideband signal is now established. Straight r.f. amplification occurs through *V4*.

Following is an elaborate system of heterodyning to provide three functions: (1) to raise the nominal 7.5-mc. signal to operating frequency on 27 mc.; (2) provide a method of selecting sidebands; and (3) to make sidebands selectable with only one crystal per channel. The circuitry bases its operation on the fact that when the 7.5-mc signal is *added* to a mixing frequency to produce 27 mc., the output contains the *upper* sideband. Here is an example with figures given earlier: The SSB signal emerging from *V4* is 7.501 mc. This is applied to *V5*, the transmit mixer. Note that channel oscillator *V6* also feeds the mixer (through a selector switch). As shown, the frequency of the channel oscillator is 19.5 mc. The two signals are heterodyned by *V5*—7.501 plus 19.5—producing a 27.001-mc. result. This action occurs when the operator desires to transmit on the upper sideband. Since an operating frequency of 27 mc. is assumed, we note that 1-kc. audio appears in the correct position, *i.e.,* 1000 cycles above operating frequency.

Now to take the same channel oscillator frequency and create a lower sideband signal on 27 mc. (In effect, one channel crystal will be made to yield either sideband.) This is accomplished by several additional steps which convert 19.5 mc. to 34.5 mc. in the following fashion: Oscillator *V1* is generating 7.5 mc. for production of sidebands. But part of the oscillator signal is also fed to doubler *V17*, where it multiplies to 15 mc. This is applied to mixer *V16A* which simultaneously receives the original 19.5-mc. channel oscillator signal. Add the two—19.5 and 15—and 34.5 results. Given 34.5 mc., the transmit mixer can heterodyne it with the SSB signal on 7.501 mc. to produce a difference frequency. It is 26.999 mc., the lower sideband for 1-kc. audio on an operating channel of 27 mc. Thus, the proper choice of mixing frequencies readily positions the sideband above or below the desired 27-mc. transmission channel. Linear r.f. amplification by *V15* and *V7* preserves the AM waveform and the sideband signal is transmitted.

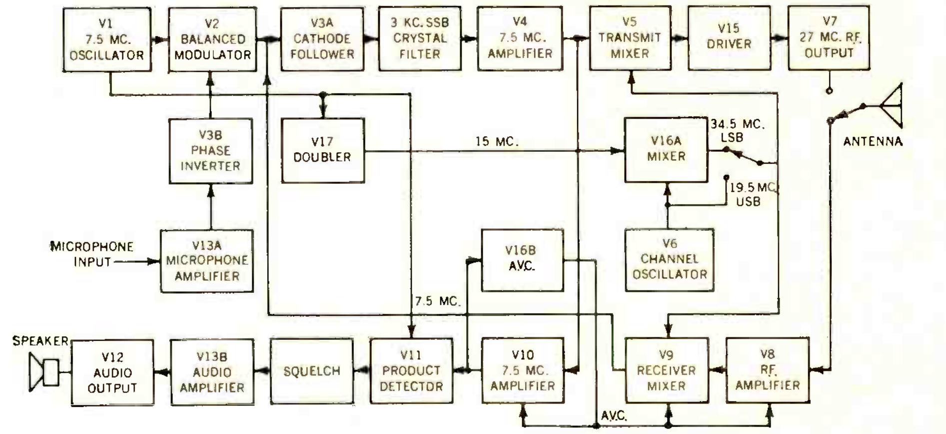


Fig. 1. The Mark SSB transceiver shown here in lower-sideband mode.

The frequencies given are convenient for illustrating circuit performance only, because there is no authorized CB channel precisely on 27 mc. Since channels exist just above and below 27 mc., crystal frequencies in channel oscillator *V6* actually cluster around the 19.5-mc. value used in the example.

The "Sidewinder" receiver section differs significantly from conventional CB circuits in several respects. First is the local oscillator. Not only does it heterodyne an incoming signal down to i.f. frequency, but it provides a means of selecting the upper or lower sideband of a given received channel. The process is nearly identical to the one already described for the transmitter and, in fact, the same oscillators and crystals are employed. We'll assume that an upper sideband signal on 27.001 mc. is applied to receiver mixer *V9*. The operator, in selecting upper sideband, causes 19.5 mc. to couple from *V6* to the receiver mixer, *V9*. The difference—19.5 from 27.001—is the desired i.f. of 7.501 mc. To receive the *lower* sideband of the same 27-mc. operating channel: 26.999 mc. (incoming frequency) subtracts from 34.5 and the result is again 7.501. It is important to note that whether upper or lower sideband is selected, the heterodyne process in either case positions the signal *above* the nominal 7.5-mc. i.f. (This is a requirement of the crystal filter, described below.)

It is advantageous to run the i.f. signal through the 3-kc. crystal used earlier to attenuate one sideband during transmit. This is crucial for realizing the full gain possible with an SSB system. By narrowing i.f. bandpass to 3 kc., the reduction in receiver noise is tantamount to increasing the transmitter power. The filter also assures that adjacent-channel signals and the alternate sideband are rejected. The path for filtering is from receiver mixer *V9*, through *V3A*, crystal filter, i.f. amplifier *V4*, and down to i.f. amplifier *V10*.

The detection process follows. *V11* is a product detector, commonly found in SSB receivers. Unlike normal diode detectors it is not subject to signal overload in the mixing process. It will be seen that output of the 7.5-mc. oscillator at *V1* feeds the product detector along with the 7.501-mc. incoming frequency. Mixing recovers the transmitted audio—a 1-kc. difference between the two r.f. signals.

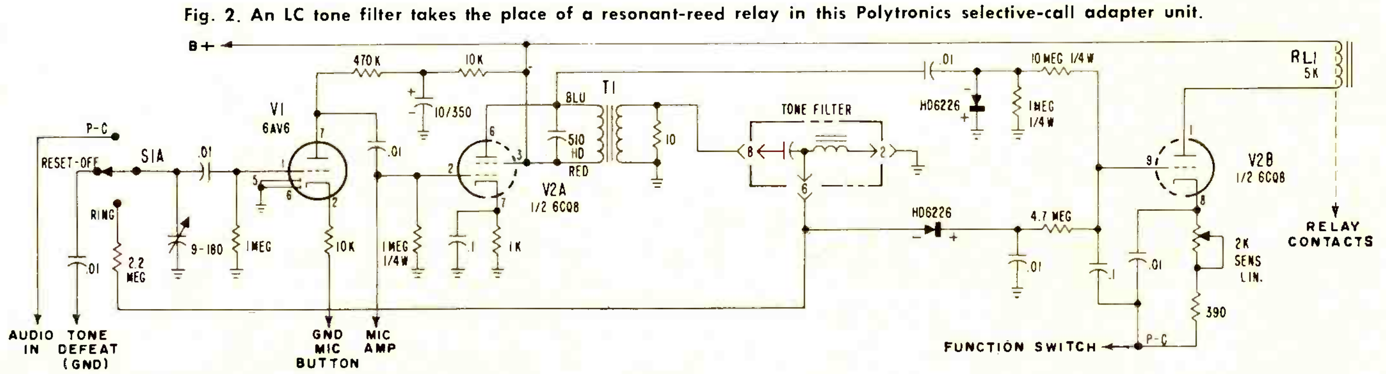
These are the major circuits of the "Sidewinder" for creating and detecting the sideband signal. An interesting aspect of operation is the number of crystal channels available to the operator. In the conventional CB rig, a 5-channel transceiver usually means that 10 crystals are needed—five for transmit and five for receive. The "Sidewinder" is also a 5-channel transceiver but five crystals provide frequencies for 10 transmit and 10 receive channels. From the preceding discussion, it is apparent that each crystal functions for both transmit and receive. This accounts for ten crystal frequencies. But the total is driven up to 20 if it is recalled that each of the five crystals can develop an upper and lower sideband for transmission or for reception.

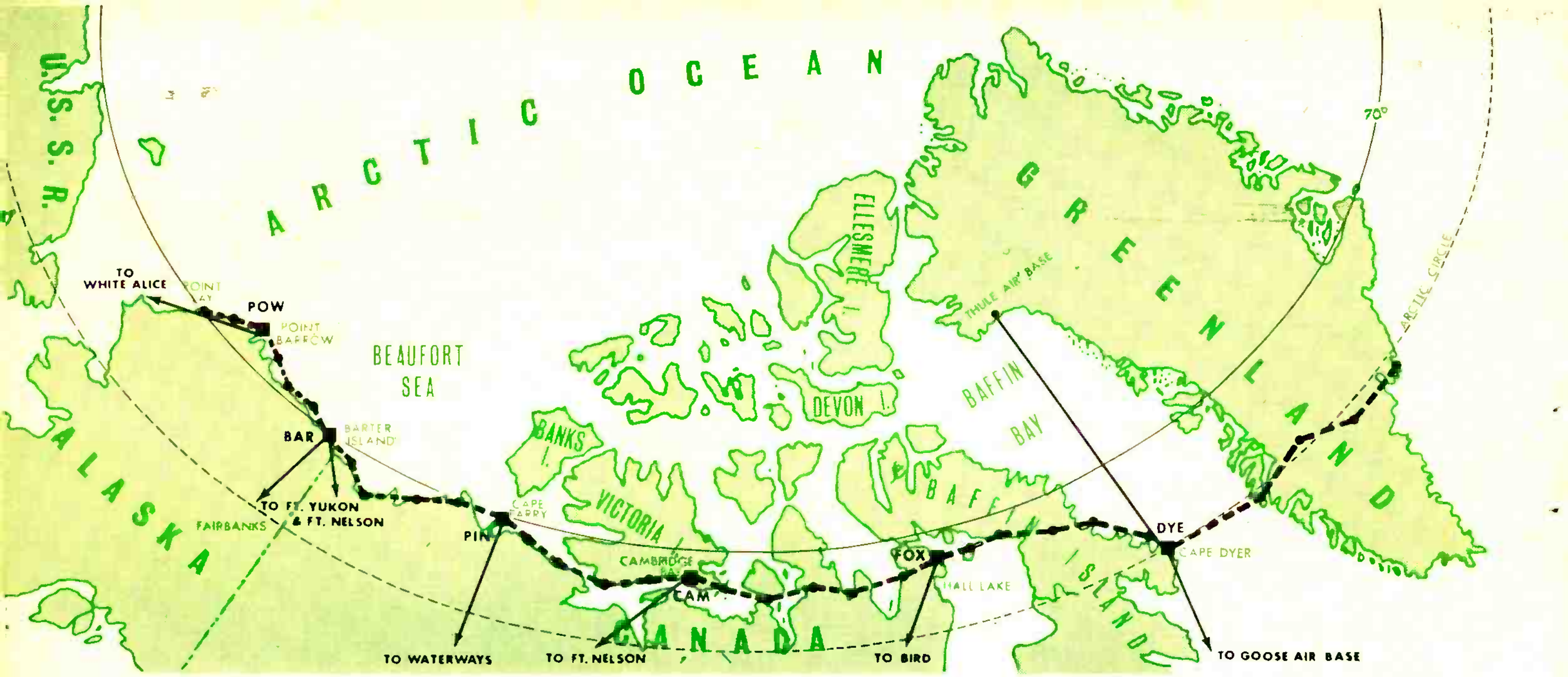
(b) "Poly-Call" Adapter

Nearly all of today's dozen or so selective call systems for CB are designed around the resonant-reed relay. In operation, a thin strip of metal is set into natural vibration by electromagnetic forces generated by a received audio tone. Resonance of the reed produces mechanical switching action. *Polytronics,*[2] however, has elected a different technique in its "Poly-Call" adapter. Switching contacts are eliminated in favor of an all-electronic method for tone selection and generation.

The design revolves around the *LC* circuit marked "tone filter" in the schematic of (*Continued on page* 74)

Fig. 2. An LC tone filter takes the place of a resonant-reed relay in this Polytronics selective-call adapter unit.





Map showing the various stations of the Distant Early Warning (DEW) Line along with the six main "Data Center" stations.

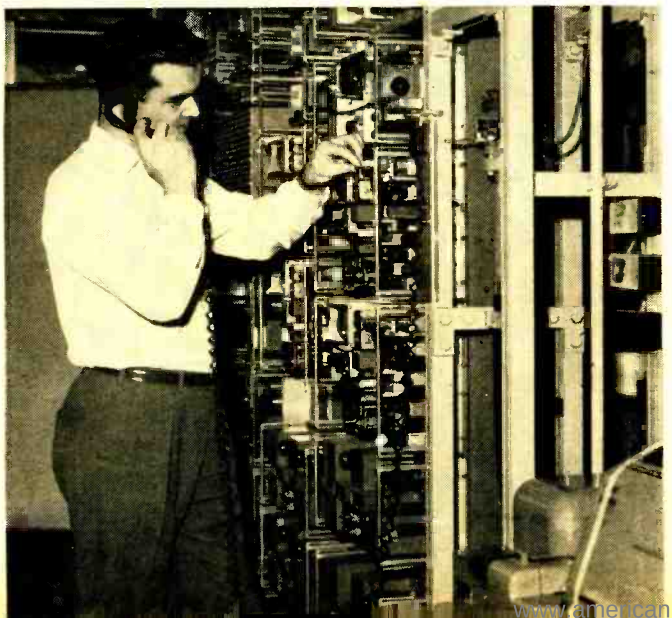
"RADICIANS" AT THE DEW LINE

By WILLIAM A. STOCKLIN

As an official guest of the U.S. Air Force, we saw radar and communications technicians service, maintain, and operate all types of DEW Line equipment.

The mission of the Distant Early Warning (DEW) Line is to detect, identify, and report to NORAD commanders any aircraft penetrating our northern defense line. Some 33 individual radar sites, spaced in an arc directly above the Arctic Circle, extend 3290 miles across Alaska, Canada, and Greenland. It was constructed by Western Electric Company and turned over to the U.S. Air Force in 1957. Since then it has been operated and maintained by the Federal Electric Corp. (Division of ITT) under contract with the Air Force. It is basically contractor-operated with limited military participation.

Joseph Doucette shown at the order-wire rack of the ionospheric scatter, rearward communications system at "Cam-Main" site. He has worked 4½ years in the Arctic on all types of DEW Line equipment. Formerly Technical Instructor at the Domestic Training Center, Streator, Ill. and Training Supervisor on the DEW Line, he is now Section Installation Supervisor on new communications system for the DEW Line.



ELECTRONICS as a vocation—particularly in the areas of service, maintenance, or operation—certainly has its share of disadvantages, like any other profession. But those professionally trained and willing to accept employment in a land of snow, ice, and semi-darkness find loneliness the only demoralizing factor. All other disadvantages seem to disappear. Even the fact that temperatures may drop to −65° seems relatively unimportant.

To be physically removed from family and friends for long periods of time is an unbearable loneliness to many. Yet the 250 "radicians" (radar technicians) at the DEW Line sites find the pay exceptionally good and the work challenging. Tom Sullivan, Communications Supervisor at the Barter Island site in Alaska, summed it up very neatly: "Most of my work as a broadcast engineer in the States became routine—nothing new. Now I have all the opportunities to get practical experience with new systems including tropospheric and ionospheric scatter communications." He did admit, though, that money was also a motivating factor.

Radar & Communications Equipment

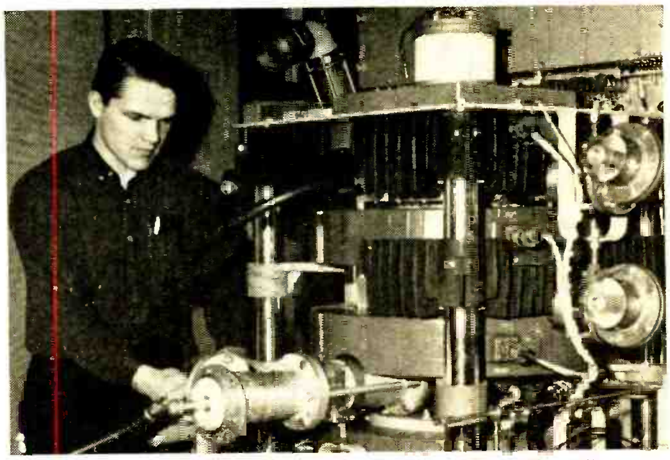
The DEW Line has 33 sites north of the Arctic Circle, all of them having similar pulsed radar search equipment. Since the DEW Line's main purpose is to detect all aircraft entering our northern defense area, the importance of the radar equipment becomes apparent. Each site has dual equipment just in case of failure in one of the units. A radician is always at the control console viewing the radar screen. This is the most important job of all. Men work in pairs on four-hour shifts. While one is operating the control console the other is doing maintenance work on the standby equipment. A large number of planes are tracked during a month across the entire DEW Line which does, in a way, break up the monotony.

Every plane planning to cross this defense area must file a flight plan. Additionally, each plane must cross the DEW Identification Zone within prescribed corollation limits (time and distance) which leaves very little room for error.

Communications, of course, play a vital role and although each of the 33 sites is connected in the system, there are six main stations referred to as "Data Centers." It is at these centers that all information on flight interception is analyzed, plotted, coded, and passed on to our North American Air Defense Command.

Ionospheric scatter systems, at v.h.f. frequencies, were being used for longer transmissions. These were employed from the "Fox" site to Bird in Manitoba, Canada; from "Cam" site to Fort Nelson in British Columbia; from "Pin" site to Waterways in Alberta; and from "Bar" site to Fort Nelson, Ft. Yukon and to Anchorage, Alaska.

In addition to the maintenance, servicing, and operation of these systems, radicians are called upon to perform similar functions on pulse system navigational aids, aircraft guidance equipment, weather bases, and emergency maintenance. The "friend-or-foe" identification system, although it is serviced and maintained by contract technicians, is operated by the military. In most of these areas, the radicians may be called upon to plan, install, operate, and maintain or instruct other personnel in taking over operation and upkeep. They may even be asked to climb ice-covered masts in order to adjust the communications antennas.

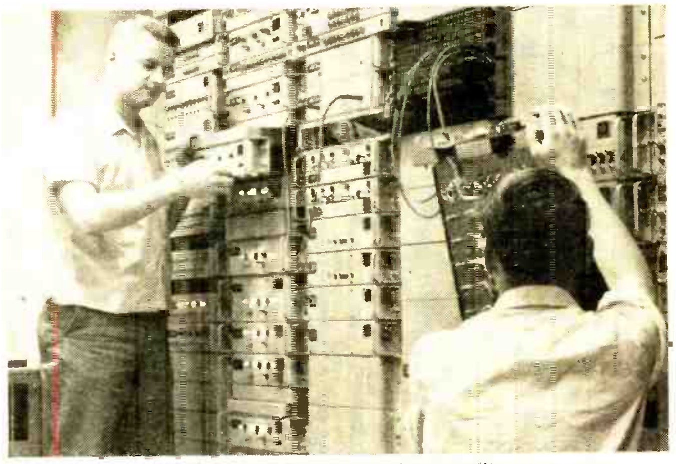


Larry Davis of Klamath Falls, Oregon, obtained his radio-relay and microwave experience at USMC school. He is one of eight technicians trained to man the "Bar" terminal of the "Bar"-Fort Yukon system. He is shown checking a spare klystron tube made by Eimac Corp. It is a standby unit placed in front of transmitter preparatory to quick insertion in case of any failure of the klystron in the main transmitter.

Requirements and Qualifications

Obviously, the sort of individual who can handle such responsibilities is not a carefree person just seeking excitement. A taste for adventure is an asset, of course, but most important is technical knowledge and an ability to work alone with a sense of responsibility. To obtain such men and to train them for the work to be done is the responsibility of *Federal Electric Corp.*, a division of *International Telephone Telegraph Corporation*. *FEC* is basically a service organization and its contract (which runs to about $25 million this year) with the Air Force is to supply, maintain, and operate all facilities on the DEW Line.

Most *FEC* technicians have had previous electronic training in either the military or some area of industry, or highly specialized vocational schooling. Communications specialists are in great demand and any technician with a solid background in this area is a choice applicant. Formal education at a college or technical training institute is most desirable. A background confined to only training or experience in consumer equipment service would not be generally adequate. Math seems to be desirable. Courses in algebra, trigonometry, geometry, and even calculus, condition one's mind to think along technical lines.

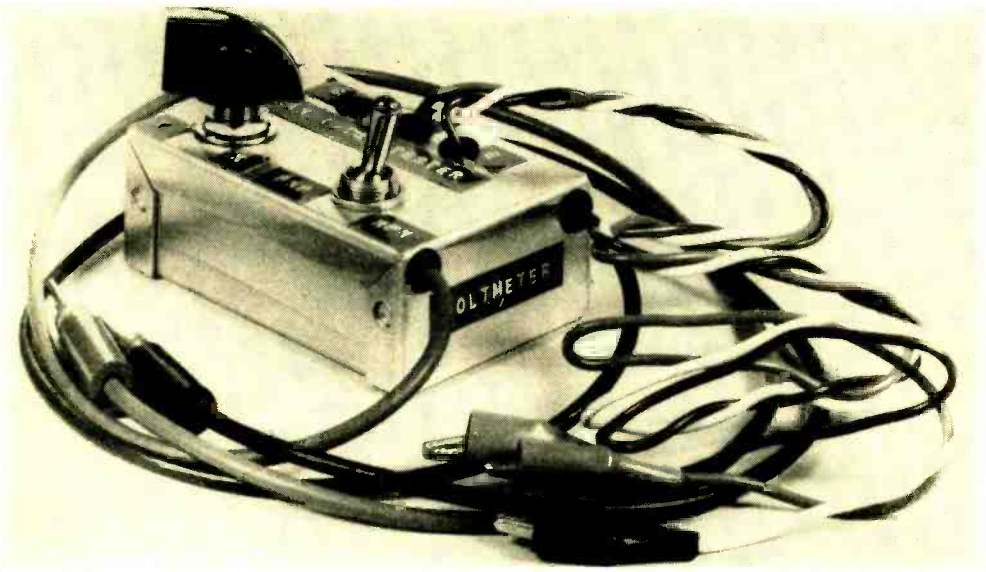


Brian Marshall (left) and John Sheridan installing new transistorized frequency stacking multiplex system built by Lenkurt. Brian Marshall is lead electronics technician at the "Cam" site, with previous communications training with the RCAF. John Sheridan is a project installer and has been on the DEW Line only five months. He has had previous communications training with Marconi Wireless Telegraph, England.

Although technical ability is most important, all applicants are carefully screened with regards to temperament and outlook. Liking and getting along with people is important. These men not only have to work together as teams, but actually live together months at a time. Extremists in any form are undesirable. Every technician considered for DEW Line service must be physically and mentally sound and extensive tests are given prior to acceptance.

Age and marital status are relatively unimportant. The average age of DEW Line technicians is near 31, and almost 70 percent are married. Obviously, the single person is apt to have fewer family ties and outside worries, yet the married man has proven somewhat more reliable. Most of the responsible positions are handled (*Continued on page 80*)

The DEW Line base "Dye 1" located on the east coast of Greenland. The four billboard-like structures are the forward-scatter antennas that are employed for communications. Within the dome at the center is radar antenna.



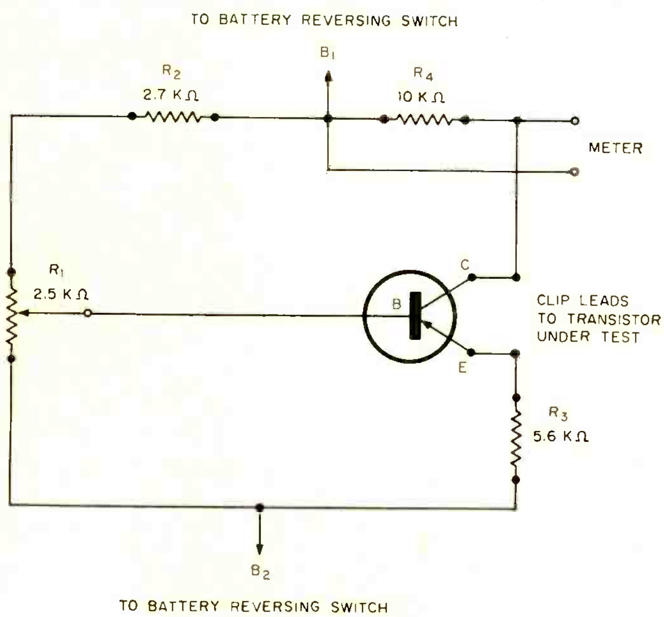
Simplicity is the keynote in this portable transistor tester.

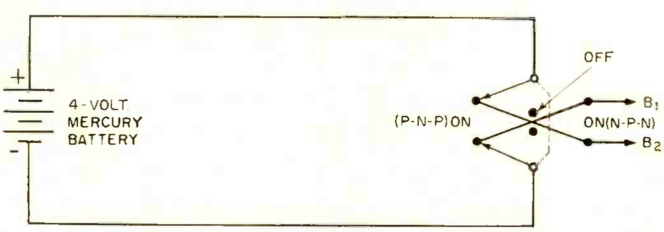
SIMPLE TRANSISTOR TESTER

Compact transistor conductance tester needs only an external voltmeter to be put into operation.

By J. E. CONTENT
Westinghouse Defense and Space Center
and
B. K. MORSE

A voltage divider network tests transistor for conductance.





DESIGNED to be compact, reliable, and inexpensive, the portable transistor checker shown in this article was designed by *Westinghouse* for use by their field-service personnel. The only other piece of equipment required is a conventional v.o.m. or v.t.v.m.

While not producing any numerical values for the transistor being tested, the unit will show if the transistor is operating properly as its base potential is varied. This tester can also be used to indicate shorts and opens between the transistor elements, and is capable of testing diodes, *n-p-n* or *p-n-p*, *n-p-n-p* or *p-n-p-n*, unijunction, and gate transistors.

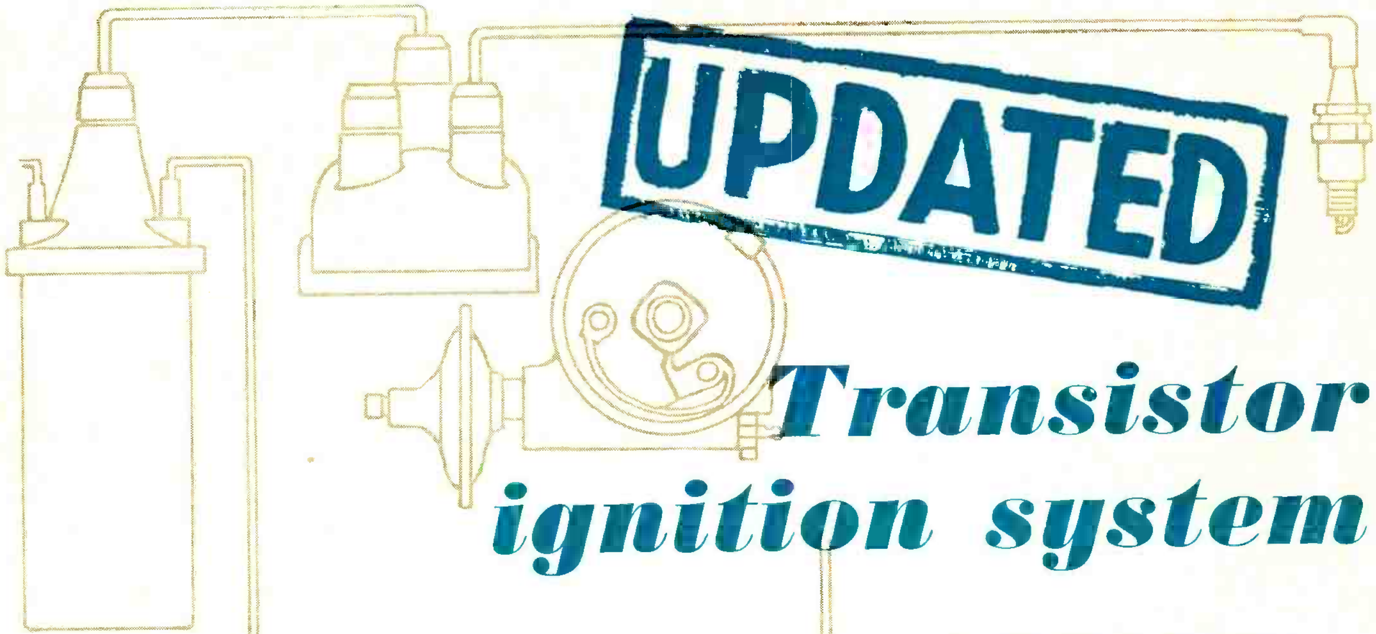
In principle, the tester uses the transistor in a voltage-divider circuit and because negligible current flow is involved, the transistor under test cannot be damaged by incorrect connections or a short.

The unit is housed in a small chassis box, 3¼ by 2⅛ by 1⅛ inches in size. A double-pole, double-throw switch changes potential for testing *n-p-n* or *p-n-p* types. The external v.o.m. or v.t.v.m. should be set to measure about 1 to 2 volts d.c.

Resistor *R3* (see schematic) prevents excess emitter current while *R2* limits forward bias to the base. Potentiometer *R1* provides the reverse-to-forward base bias. Resistor *R4* limits the transistor load, stabilizes the readings, and provides the voltage that is read out by the external voltmeter. Resistors *R1* and *R2* make up a voltage divider. With the circuit shown, any change in conductivity between the transistor collector and emitter will then show up as a reading on the external voltmeter.

If the transistor under test has an open collector circuit, the meter will indicate zero. If the emitter circuit is open, the meter reading will remain unchanged when the emitter test lead is disconnected. Short circuits between transistor elements are indicated by high meter readings.

A good transistor will produce a reading somewhat less than the short-circuit value when only the collector and emitter leads are hooked up. This value will increase when the base lead is connected and potentiometer *R1* is rotated towards the *R2* end. ▲



UPDATED Transistor ignition system

By BOGHOS N. SAATJIAN
Design Engineer, Triad Transformer Corp.

Circuit modifications that will improve the performance of the author's earlier design.

THE introduction of a transistor specifically designed for ignition systems has permitted the modification of the author's basic circuit as published in the August and December 1962 issues of ELECTRONICS WORLD.

The new transistors have an emitter-to-collector and collector-to-base voltage of 120 volts, as compared to 80 volts for the 2N174's used originally. The new units are the 2N1073B's, available from several companies. Because they are rated at only 10 amps, two of them have to be used in parallel. Any moderate imbalance between transistors would not affect operation of the circuit; therefore, they are connected together, base-to-base, emitter-to-emitter, and collector-to-collector without the use of small-value resistors in series with the emitters. The values of the bias resistors were also changed.

The use of 2N1073B's improves performance of the circuit by allowing the use of a zener diode having a higher voltage rating. This will permit a higher self-induced voltage at break in the primary of the ignition coil which, in turn, will generate a higher secondary voltage. By using a 400:1 turns-ratio coil, a full-load secondary voltage of between 27,000 and 30,000 volts was obtained from idle to 4500 rpm.

The 100-pf., 500-volt non-inductive mica capacitor was retained to protect the transistors from high-frequency spikes.

A 50-μf., 150-200-volt electrolytic capacitor was added at the input of the circuit to damp any spikes generated in the electrical system of the car by the voltage regulator, generator, starter and its relay, and the horn.

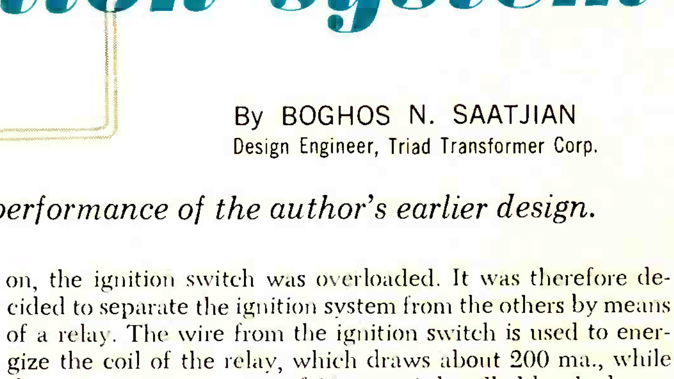
The two transistors are mounted on a common heat sink designed for two transistors. Silicone grease is used between the transistors and the heat sink. Another heat sink is used for the 25-amp rectifier and once more silicone grease is applied between it and its heat sink.

The voltage value of the zener diode is now raised to 100 volts at 10 watts. The zener diode in this power rating comes with a stud mounting. It should be mounted on the same heat sink with the transistors and short leads used to connect it to the emitters and collectors of the two transistors in parallel.

Another addition to the author's original circuit is the power relay. After several months of operation with the original circuit, it was discovered that the ignition switch on the car was getting hot, due to the increased current requirement of the transistorized ignition system. With the auto accessories on, the ignition switch was overloaded. It was therefore decided to separate the ignition system from the others by means of a relay. The wire from the ignition switch is used to energize the coil of the relay, which draws about 200 ma., while the main ignition current of 10 amps is handled by the heavy contacts of the relay. If the wire connected to the ignition switch is also a ballast resistor, there is no need to bypass this as 200 ma. through the wire will not develop any appreciable voltage drop and the relay coil will still operate at the lower voltage. (There was only a 0.36-volt drop across the ballast resistor at 200 ma.) If a regular ballast resistor is used, this need not be shorted out.

If it is decided not to use a relay as suggested, the original ballast resistor, in any form, should (*Continued on page* 80)

Transistor ignition system for 12-v. negative-ground systems.



R1—0.5 ohm, 100 w. adj. res.
R2—30 ohm, 5 w. wirewound res.
R3—300 ohm, 5 w. wirewound res.
R4—5 ohm, 25 w. wirewound res.
C1—50 µf., 150-200 v. elec. capacitor, 85-100° F operating temperature
C2—100 pf., 500 v. non-inductive mica capacitor (Use flat molded type such as Aerovax CM-20B-101 or Arco-Elmenco CM-15-E-101J)
RL1—12-volt headlight relay. (Available at auto parts dealers) Use 6-v. relay for 6-v. systems.
S1—Car ignition switch
B1—12-volt neg.-ground car battery
P1—Male and female Jones plugs (Jones P-303-CCT & S-303-CCT)
D1—Silicon rectifier, 150 v. p.i.v., 25 amp. (International Rectifier 25HB15 or equiv.)
D2—100 v., 10 w. zener diode (International Rectifier 1N3005A or equiv.)
T1—Molded ignition coil, 400:1 turns ratio (Slep Electronics Company, P.O. Box 178, Ellenton, Florida. Type No. F-400T or equiv.)
Q1, Q2—2N1073B power trans. (Delco Radio or equiv. Price approx. $4.50.)
1—Two-transistor heat sink (Asto-Dynamics, Northwest Industrial Park, Burlington, Mass. Type No. 2513 or equiv. West Coast dist. Electro-Space, Inc., 239 S. Robertson Blvd., Beverly Hills, Calif.)
1—Heat sink for 25-amp rectifier.

TUBE	REGULATING VOLTAGE	CURRENT OPERATING RANGE (ma.)	MIN. D. C. SUPPLY VOLTAGE
0A2	150	5-30	185
0A3	75	5-40	105
0B2	105	5-30	133
0B3	90	5-40	125
0C3	105	5-40	133
0D3	150	5-40	185

Table 1. Characteristics of commonly used regulator tubes.

VOLTAGE REGULATOR DESIGN

By LOUIS E. FRENZEL, JR. / McCollum Laboratories, Inc.

Operation of VR tubes and zener diodes along with examples of basic circuit design using Ohm's Law.

VOLTAGE regulators are used in almost all types of electronic equipment, their purpose being to control the d.c. power-supply voltage and to keep it constant. Many circuits require a stable supply voltage for proper operation. A good example is an oscillator whose frequency must not vary during operation. Since a change in supply voltage generally causes a frequency variation, steps must be taken to regulate the supply. Best circuit stability occurs when the supply voltage remains constant despite changes in load current or variations in the a.c. line. In many cases, too, circuit design can be simplified if it can be assumed that a regulated supply will be used.

A voltage regulator is a circuit or device connected between the power supply and the load. It absorbs any voltage or current variations that occur in normal operation and keeps the load voltage constant. There are many different kinds of regulators, but the ones described here are the simplest and most commonly used. These circuits use gas regulator tubes or zener diodes and are so common that they will be encountered often. Knowledge of their operation and design will be helpful to anyone involved in electronics.

What is Regulation?

Regulation is a term used to describe the ability of a power supply to maintain a constant output voltage under varying load conditions. It is usually expressed as a percentage and can be calculated from the formula:

$$\%\ regulation = \frac{E\ (no\ load) - E\ (full\ load)}{E\ (full\ load)} \times 100$$

where *E* (*no load*) is the power-supply output voltage when no load is connected and *E* (*full load*) is the output voltage when maximum load is applied. To illustrate, assume that a power supply has an output voltage of 250 volts with no load. When a load is connected, suppose the voltage drops to 200 volts. Putting these values in the formula gives:

$$\%\ regulation = \frac{250-200}{200} \times 100$$

$$\%\ regulation = \frac{50 \times 100}{200} = 25\%$$

This percentage gives us a figure of merit for comparing the regulation of power supplies. The lower the percentage the better the regulation.

Poor regulation is caused by the high internal impedance of the power supply. When a power supply is operating without a load, no current is being drawn from it and a certain voltage appears at the output. But when a load is connected, current is drawn from the supply and the output voltage drops. The current flowing in the supply produces voltage drops across the power transformer windings, the rectifier, and the chokes or resistors in the filter. These voltage drops subtract from the voltage normally available under no-load conditions. If the load is increased, additional current is drawn from the supply, and the voltage drops in the supply increase, leaving an even smaller voltage at the output.

Another condition that causes output voltage changes is varying line voltage. Often the a.c. line voltage feeding the supply will change and this undesired variation will be transferred through the supply to the load.

Both varying load requirements and changing line voltage conditions are undesirable and, in some cases, intolerable. Voltage regulators of various designs are available to minimize or eliminate this voltage variation.

VR-Tube Regulator

The most commonly used regulator circuit is shown in Fig. 1. It is extremely simple and inexpensive and makes a very desirable addition to almost every piece of electronic equipment. The circuit uses a special voltage-regulator (VR) tube which is a cold-cathode, gas-filled tube. If a high enough voltage is applied across the tube, the gas will ionize and current will flow between cathode and plate. Once the tube is ionized, the voltage across it remains practically constant regardless of current and ionization changes in it. This unique characteristic makes it a desirable regulating element.

The VR tube is essentially a variable resistor that changes its resistance in such a manner that the voltage across it remains constant as the current through it varies. Varying current in the tube causes the degree of ionization of the gas and hence the resistance of the tube to change. The current range over which the voltage remains constant is limited, of course, but the range is a useful one.

The regulator tube is connected in series with a limiting resistor *R*1. The tube and the resistor form a variable voltage divider. The power-supply voltage applied to this series combination must be high enough to ionize the tube. The initial tube firing voltage is usually about 30% higher than the regulated voltage, E_R. The load is connected across, or in shunt with, the VR tube.

To understand the operation of a properly designed shunt VR-tube regulator circuit, like that of Fig. 1, assume that the power supply is turned on, the VR tube is ionized, and no

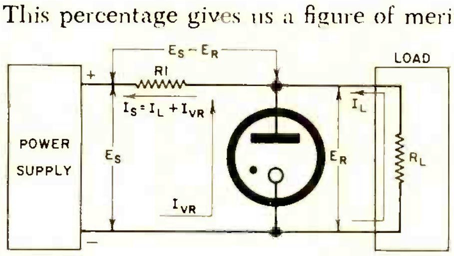


Fig. 1. Simple VR-tube voltage-regulator circuit showing load current (I_L), VR tube current (I_{VR}), and total supply current (I_S).

load is connected. The voltage across the tube is its rated value. Under these conditions, maximum current flows in the VR tube and the value of $R1$ should be high enough so that the tube will not be damaged.

If a small load (high resistance) is connected across the VR tube, it draws current through $R1$ from the supply. The voltage drop across $R1$ tends to increase, leaving, for an instant, less voltage on the VR tube. Immediately, the VR tube compensates by de-ionizing somewhat, increasing its resistance. The current through the VR tube decreases, offsetting the current increase caused by the load. The voltage across the VR tube and load remains the same since the total current drawn from the supply through $R1$ stays constant. Increasing the load further (lowering load resistance) causes it to draw more current through $R1$. Again the VR tube de-ionizes some and draws less current, correcting for the increased load current.

If the load current should decrease, the current through $R1$ would tend to decrease as would the voltage across it. The VR tube and load voltage would, for an instant, try to increase. The VR tube senses this increase and ionizes more, lowering its resistance. The lower VR tube resistance causes it to draw more current thereby correcting for the decrease in load current. Keep in mind that this VR-tube regulating action takes place almost instantaneously so that with even the most rapid load voltage changes the supply voltage remains constant.

The regulating action of the VR tube is somewhat different under changing line voltage conditions. If the load current is constant and line voltage drops suddenly, the VR-tube voltage tends to drop and the tube de-ionizes slightly. The tube resistance becomes higher and the tube draws less current. Less current through $R1$ means a smaller voltage drop across it. Therefore, the drop in line voltage is compensated. An increase in line voltage would result in greater tube ionization and current. The larger current in $R1$ causes a larger drop across it and less voltage across the VR tube and the output load, thereby correcting for the initial increase.

VR-Tube Regulator Design

It is easy to design a VR-tube regulator like the one in Fig. 1, since all that is involved is selecting the right value for $R1$ under specified supply and load conditions. Only simple Ohm's Law calculations are involved.

VR tubes are available to regulate voltages at 75, 90, 105, and 150 volts. There are several other special units made, but the four voltages mentioned are the most common. These tubes require a specified minimum supply voltage and must be used over a set current range. Table 1 shows the most common VR tubes and their ratings. The 0A2 and 0B2 are 7-pin miniatures, the others are conventional octal base types.

$R1$ is chosen so that the maximum current rating of the tube will not be exceeded when there is no load connected across it, and so that a specified minimum current will flow in the tube under maximum load conditions.

As indicated in Table 1, the current through the tube must not exceed 30 or 40 ma., depending on the tube used. Also, each tube must have at least 5 ma. flowing in it to maintain ionization and regulation. The maximum current condition will occur with no load applied across the tube, while the minimum current condition appears under full-load conditions. In order to meet the minimum current requirement, the load current cannot exceed a value equal to 5 ma. less than the maximum allowable current. This is 25 ma. for the 0A2 and 0B2, and 35 ma. for the 0A3, 0B3, 0C3, and 0D3. The value of resistance ($R1$) can be calculated from the formula:

$$R1 = \frac{E_S - E_R}{I} \qquad (1)$$

E_S is the minimum unregulated supply voltage expected under load, E_R is the regulating voltage or VR-tube rating, and I is the maximum allowable tube current as shown in Table 1.

A design example will best illustrate the use of this formula.

Problem: Design a 150-volt regulator for an oscillator circuit that requires 10 ma. of current for operation. An unregulated 315-volt (open circuit) supply is available.

Solution: First, choose a regulator tube. In this case either the 0A2 or 0D3 can be used since they are both rated at 150 volts and can handle the current. Let's select the 0A2 since it is smaller physically. Next, determine the minimum loaded, unregulated supply voltage. The 315-volt value cannot be used in the formula since it is an open-circuit value. The supply voltage under load will be less. A maximum of 30 ma. could be drawn from the supply. This may be the oscillator current plus the tube current under ordinary operating conditions or the maximum tube current only if the oscillator load should be removed from the supply. To determine the supply output voltage under a 30-ma. load, simply connect a variable resistor and a milliammeter, in series, to the output of the supply. Vary the resistance until the meter reads 30 ma. Then measure the supply voltage. Assume that in this case it is 300 volts. Putting this value into the formula, along with the maximum tube current, gives:

$$R1 = \frac{300 - 150}{.03} = \frac{150}{.03} = 5000$$

or an $R1$ value of 5000 ohms. In order to select the proper resistor for the circuit, its power handling capabilities must also be considered. Using the well-known power formula $P = I^2R$, the needed rating can be found. I is the maximum supply current expected—30 ma. (.03 ampere) for this example.

$$P = (.03)^2\, 5000 = (.0009)\ (5000) = 4.5 \text{ watts}$$

A standard 5- or 10-watt unit would be satisfactory.

Most VR-tube regulator circuits are designed using this procedure, but there are variations for solving a wider range of regulation problems.

For example, you may wish to regulate voltages other than those for which VR tubes are available. In this case, VR tubes can be connected in series, as in Fig. 2. Two 150-volt 0A2's can be put in series to regulate 300 volts, or three 0B3's in series can be used to regulate 270 volts. An 0A2 and 0B2 in series will regulate 255 volts.

Any series combination can be used just as long as the tubes have the same current range. The design procedure is the same except for E_R you substitute the series-voltage rating of the VR tubes. Be sure that the supply voltage is approximately 30% higher than the series-voltage combination so that the tubes will ionize.

The big disadvantage to the design procedure just described is that the load current must always be smaller than 5 ma. less than the maximum current rating of the VR tube(s) used. The load current must not exceed 25 ma. for 0A2's and 0B2's or 35 ma. for 0A3's, 0B3's, 0C3's, or 0D3's. While these current ranges are quite suitable for many applications, there will still be cases where you may need to regulate the voltage on a load carrying much greater current.

The most logical solution to this problem appears to be simply a matter of paralleling similar VR tubes. While such

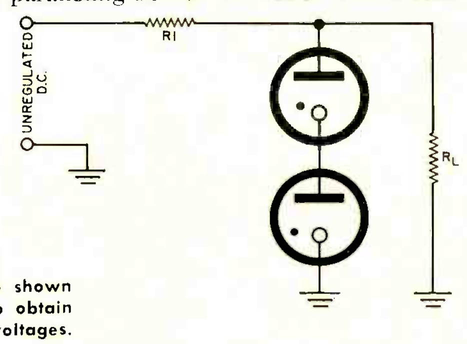


Fig. 2. VR tubes are shown connected in series to obtain regulation at higher voltages.

a procedure is theoretically sound, it is not suitable in practice. The difficulty is finding similar VR tubes with identical ratings. VR tubes have wide tolerances and finding two or more with exactly the same ionization and regulation voltages is difficult. If non-identical tubes are used, the circuit would function poorly if at all and there is a chance that one of the tubes could be damaged. This problem can be overcome to some extent by using small (50 to 100 ohm) resistors in series with the VR tubes, as shown in Fig. 3. These resistances, whose values must be determined experimentally, help to equalize the VR-tube characteristics. But these resistors also reduce considerably the regulating efficiency of the tubes. Such an arrangement is generally unsatisfactory except perhaps where poor regulation is better than none at all.

The design procedure to be described will overcome the disadvantage of being limited to small load currents. With this procedure you will be able to design single or series-connected VR-tube circuits with load currents much greater than 25 to 35 ma.

In this design, the problem again is to select the proper value of $R1$. This is easily done by Ohm's Law if the voltage across $R1$ and the current through it is known. From Kirchhoff's Laws we know that the voltage across $R1$ is equal to the supply voltage minus the load voltage, and the current through $R1$ is the sum of the load and VR-tube currents. See Fig. 1. Using this relationship, the formula for finding $R1$ is:

$$R1 = \frac{E_S - E_R}{I_L + I_{VR}} \quad (2)$$

In this formula, as in the previous one, E_S is the unregulated d.c. supply voltage under maximum load and E_R is the load and VR-tube voltage. I_L is the load current and I_{VR} is the VR-tube current. E_S under maximum expected load is found using the same procedure described before. Be sure that E_S is high enough under load to ionize the VR tube(s). E_R and I_L are known from the problem, while I_{VR} is usually set approximately to the middle of the VR-tube operating current range. This is 17.5 ma. for 0A2's and 0B2's and 22.5 ma. for the 0A3, 0B3, 0C3, 0D3 series of voltage-regulator tubes.

Typical Design Example

As before, a typical design example will best illustrate the use of this procedure.

Problem: Design a regulator to stabilize the voltage for an instrument whose supply requirements are 210 volts at 50 ma. A 350-volt unregulated supply is available.

Solution: Two series-connected 105-volt 0B2's will regulate at 210 volts. Each tube will carry the same current since they are in series. The tube current is chosen as 17.5 ma.

Determine the unregulated supply voltage under load as before. Assume that it is 290 volts when 67.5 ma. is drawn from it. (Remember the total supply current is the sum of the tube and load currents 17.5+50=67.5 ma.)

Placing these values in the formula gives us:

$$R1 = \frac{290 - 210}{.050 + .0175} = \frac{80}{.0675} = 1185 \text{ ohms}$$

The power rating of this resistor is determined from:

$$P = I^2R = (.0675)^2\ 1185$$

$$P = (.00456)\ (1185) = 5.4 \text{ watts}$$

A 10-watt unit should be used.

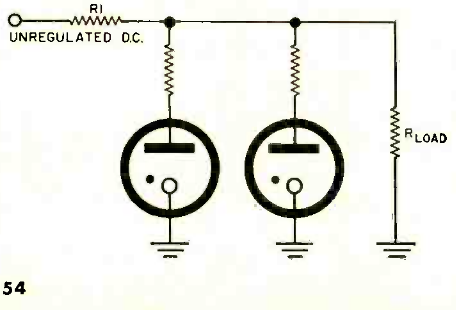
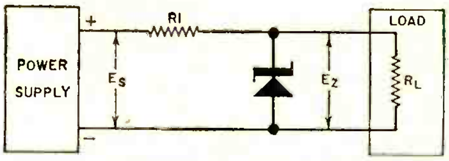


Fig. 3. Parallel connection of VR tubes employed to handle higher load currents.

Fig. 4. Basic zener diode regulator circuit design.



The actual resistance value of $R1$ can be juggled a bit since the VR-tube current range can handle any small variation. For example, in this case a 1200-ohm unit would do.

Caution: The thing to be careful of when using such a design is to see that the load is never removed or becomes open. If this should happen (or if the load current is reduced or the a.c. input line voltage is increased), the VR tubes would be damaged since $R1$ will be too small to limit the current to a safe value.

There are two points to keep in mind when designing and using VR-tube regulator circuits. First, the VR tube will regulate at its rated voltage only if the current in it stays within the operating limits given in Table 1. The load current or line voltage (or both) may change over fairly wide limits, but as long as the VR-tube current stays within its operating range, regulation will take place. Second, the regulation is not perfect. Over the current range the VR-tube voltage may change several volts. The percentage of regulation, however, is still from 1 to 10% (depending on the tube used) and this is quite satisfactory for many applications. Better regulation is obtainable only with more complex tube or transistor circuits.

Neon glow lamps, like the common NE-2 or NE-51, can also be used as voltage regulators. They are very similar in operation to the VR tube, but they do not regulate as well. Their advantages are small size and low cost. They are useful in applications where only a minimum of regulation is needed. These lamps are available in voltage ratings of 50 to approximately 80 volts. The actual value of the regulating voltage varies quite widely from unit to unit and some care must be taken in the selection of these devices. Like VR tubes, they may be connected in series to regulate higher voltages. Neon lamp regulator design is similar to that for VR tubes. Information on their particular operating characteristic is available from manufacturers' literature.

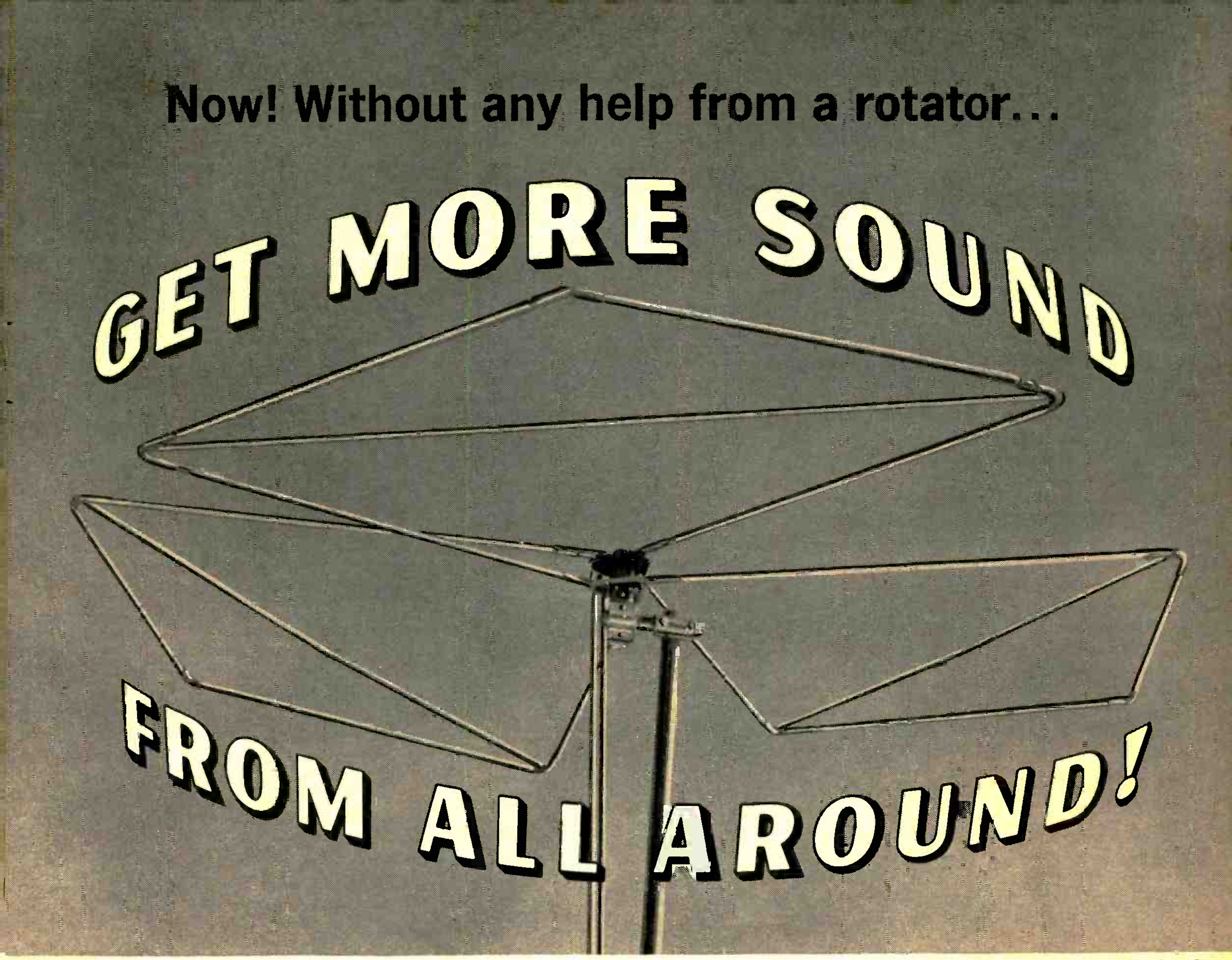
Zener Regulators

The silicon zener diode is another regulating voltage device. The resistance of this semiconductor diode varies as the current through it changes, while the voltage across it remains constant.

The zener diode is a special semiconductor junction diode that is designed to operate with a reverse bias applied to it. Conventional semiconductor junction diodes are usually operated so as not to conduct current when a reverse bias is applied to them. They act, essentially, as an open circuit or very high resistance. The zener diode, however, is made so that when a specific amount of reverse voltage is applied it will conduct. When it conducts, the voltage across it tends to remain constant despite current changes through it. This is the characteristic that makes the zener diode a regulator.

The basic zener shunt regulator circuit is shown in Fig. 4. Its configuration and operation is exactly the same as that of the VR-tube circuit of Fig. 1. Assuming a constant supply voltage, if the load current changes the zener current will also change in such a manner to keep constant the total current drawn from the supply. An increase in load current is compensated for by an increase in zener resistance and a decrease in zener current. A decrease in load current is offset by a lower zener resistance and a higher zener current. Since the total current drawn from the supply through $R1$ is the sum of the zener and load currents, the action just described is regulation—maintaining the constant current through $R1$ and a constant voltage across the zener and the load.

Variations in the supply voltage E_S are met with zener resistance and current changes to (*Continued on page* 70)



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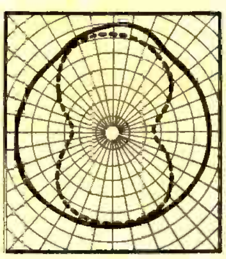

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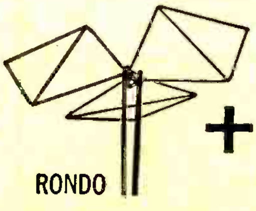

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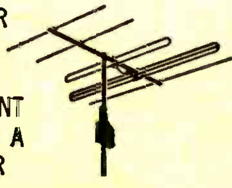

JOHN FRYE

Recent crackdowns on a few shady service operators may be a real disservice to the conscientious, ethical TV servicer.

THE FRAUDULENT TECHNICIAN—A MINORITY

"HEY, Mac, did you ever have an experience with one of those investigators who rig up a TV set with some simple complaint and then have you fix it to see if you're honest in your charges?" Barney asked his boss.

"Not that I know of," Mac answered. "Of course such a set could have gone through the shop without my being aware of it. If your repair bill seems honest, I suppose you never know. But what brought up this morbid subject?"

"Oh I was reading about a case in which a state bureau of consumer fraud received several complaints about a particular radio and TV repair concern with several branches. According to the story, three TV receivers were put in perfect operating condition, and then a defective damper tube and fuse were installed in each. The doctored sets were placed in the homes of investigators for the bureau, and three different branches of the company under suspicion were called for service.

"The bureau people figured a good technician should be able to locate and repair the trouble quickly right in the home and that $10 would be a reasonable charge. Instead, in each case, the technician said the receiver had to go into the shop; and in all instances the receivers were returned with identical $39.85 bills. What was worse, parts in a couple of the sets had been marked with ink visible only under special lighting. Examination with this light revealed that while the bills included charges for new parts, the old parts were still in the set.

"The case was taken to court, and I don't know how it came out; but doggone it! why is someone always trying to make us look bad? The Better Business Bureau in the city where this happened admitted 80% of the complaints received were made against only three-fourths of 1% of the service shops advertising in that city. In other words, one guy suspected of being crooked among a hundred and thirty honest ones louses up things for everybody! Investigations like this throw the spotlight on that one guy, and the majority of the people jump to the conclusion he's typical of the whole service fraternity. I'd not be surprised if publicity like this doesn't breed crookedness. A fellow who has been playing it straight and finds his customers regarding him with suspicion after a story such as this appears is likely to decide: 'If you've got the name, you may as well have the game.'"

"Whoa, boy; steady now!" Mac interrupted, although he was smiling sympathetically. "I appreciate how you feel, but let's not get carried away. We're human enough to dislike having anyone in our 'group' branded as a crook. Maybe deep-down we're afraid of suffering a stigma through guilt-by-association. We know that can happen. But we mustn't let this instinctive fear go far enough that we want the guilty protected from exposure."

"But why is the service fraternity singled out?"

"Actually it's not. A few black sheep turn up in every flock. Every week lawyers are being disbarred, physicians lose their licenses to practice, storekeepers and filling station operators are warned about scales or pumps that give short measure, and even a few hapless clergymen succumb to temptation. Don't forget there was a Judas among the twelve disciples. You must never allow the discovery of a few crooked service technicians to make you feel either guilty or cynical. Honesty is an individual matter. You can't hold yourself personally accountable for the honesty of every individual practicing the same trade or profession you practice. All you can do is make sure that one member of that group, yourself, is scrupulously honest, and you can place yourself squarely on record as being opposed to any shady dealing."

"Then you're not opposed to these investigations?"

"Not when they are properly conducted by responsible people and the findings are accurately and adequately reported. An example of the kind of investigation I *do not* want was one conducted several years ago by a magazine. The obvious purpose of this investigation was to come up with a sensational article that would sell magazines. The title of the article was something like 'The Radio Repairman Will Gyp You.' Note what a blanket indictment that is. It leaves the impression all radio repairmen are crooked. If you read the whole article, you found out this was not the case at all; but many never read or remembered anything but that misleading title. The lingering, bitter memory of that article probably accounts for a lot of the resentment and distrust many technicians still feel toward any attempt to unmask the few chiselers in their ranks."

"Well, I've got the feeling we're going to be in for a lot more of these investigations. Thirteen states already have Bureaus of Consumer Fraud, and more states are considering setting them up. Inasmuch as the first of these bureaus, the one in New York, was established in 1957, you can see they're spreading rapidly."

"You seem pretty well informed about them; so how's about filling me in?" Mac suggested. "How do they differ from Better Business Bureaus?"

"For one thing, a Bureau of Consumer Fraud has more teeth than a Better Business Bureau," Barney explained. "The BBB is a voluntary, self-regulating agency of business itself. While it can bring strong public opinion to bear, it cannot, by itself, dole out legal punishment. The Bureau of Consumer Fraud, on the other hand, is a state government agency directed by the state attorney general and backed by the legal power of the state. The attorney general can get an injunction to force a concern to stop its shady dealing, and he can even dissolve a corporation that persists in bilking its customers."

"What kind of investigations does the bureau make?"

"It investigates any complaint in which a customer thinks he has been cheated or swindled by a seller of goods or services. That includes everyone using worthless guarantees, bait advertising, high-pressure selling tactics, or padded service charges. Not all the complaints are found to be justified, of course; and the bureaus say that when this is the case, the customer is told his complaint is unreasonable. As the New York bureau chief, Barnett Levy, puts it: 'We won't knuckle under to a firm, but neither will we browbeat it.'"

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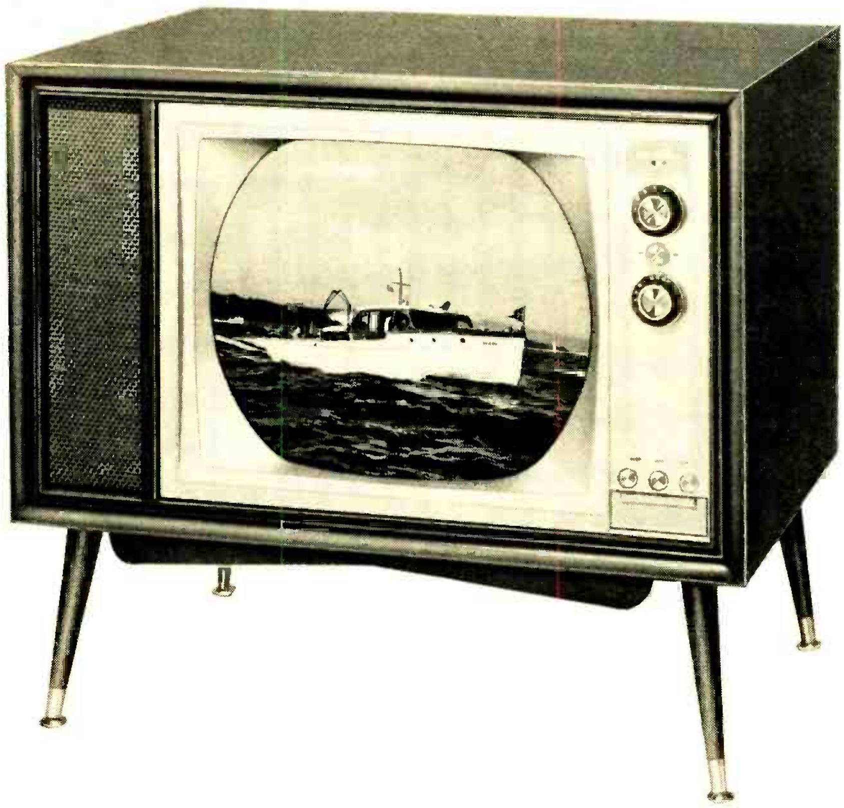

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CL-174

CIRCLE NO. 118 ON READER SERVICE PAGE

"Let's hope that will be the policy of all the bureaus, but there's just one little thing that worries me," Mac admitted. "Certainly no one can defend a technician's charging for work not performed nor for parts not installed; but when you come to deciding whether or not the technician is justified in attempting to improve the reception of any TV set, you're not on such firm ground.

"Take that business of saying a set to be used in an investigation is 'in perfect operating condition' outside of the deliberately induced faults. Quite candidly, I don't recall ever seeing a TV receiver I'd be willing to say was in 'perfect' operating condition, and I don't ever expect to see one. The layman might call the picture on it perfect, but not a trained technician. Invariably the latter would be able to point out a little non-linearity, a trace of a ghost, a suggestion of ringing, a little lack of definition, a bit of distortion or noise in the sound, etc., etc. In some cases these slight imperfections would be inherent in the set, but in other cases a decided improvement could be made if it were considered worth while."

"Yeah, and that would depend on how much of a perfectionist the technician was and how fussy he believed the customer to be," Barney added. "How often does a customer leave a 'dead' radio for repair, and after we've replaced the burned-out tube we find the set has too much hum, a slipping dial cord, or a noisy volume control? If we only put in the new tube that restores the radio to a playing condition, the customer comes bouncing back indignantly demanding if that's the way we fix sets. How about the hum? the noisy control? the slipping dial cord? It makes no difference that he failed to mention these things. He expects us to notice and correct them. Figuring out how far to go toward trying to achieve perfection is not an easy thing. Sometimes you're damned if you do and damned if you don't. And don't forget what every doctor knows: sometimes you arrive at the true cause of an infection by a process of eliminating possible and likely causes one by one."

"Truer words were never spoken! Last summer on vacation my car began to miss, and I took it to a garage. The mechanic first put in new points. Then he installed a new condenser. Next he cleaned and adjusted the carburetor. Finally he replaced a resistor-type spark-plug wire, and *that* cured the trouble. Actually all I needed to stop the missing was that new wire, but I had to pay for all the rest. And I must admit the points were rather badly pitted, the condenser showed a little leaky, and the carburetor had some dirt in it. Any one of these things could have been causing the difficulty and likely would have given me trouble later; so I paid the bill without bellyaching. I didn't feel the mechanic was trying to cheat me, and I hope he would give me the same consideration if I were working on his TV receiver."

"Well," Barney summed things up, "I guess we agree there are going to be more and more fraud investigations of all kinds of business. This is okay in the radio and TV service industry—with certain provisions: 1. An investigation should be undertaken only by a responsible government agency in response to complaints, not by witch-hunting amateurs. 2. Tests used in the investigation should be set up by people with a great deal of practical experience in service work. The technician must not be penalized for thoroughness. 3. Investigators should use a rifle rather than a shotgun to pick off the fast-buck boys. The guilty should be punished, but the innocent must be protected—hey, what are you chuckling about?"

"I couldn't help thinking we sound a little bit like Mark Twain. Remember? He said he didn't mind criticism, but it had to be his way!" ▲

EW Lab Tested

(*Continued from page 22*)

of force but any music record we had was tracked without difficulty at 1.5 grams, which was the force we used during our measurements. Intermodulation distortion was moderately low at 1.5 grams and was very low at 3 grams.

The listening quality of the "Mark IV" was essentially similar to that of earlier versions. It has a natural, unstrained quality, free from audible peaks or coloration, and with satisfactory separation. The needle talk is very low. Naturally, there is no induced magnetic hum. It is unlikely that anything but the most critical A-B tests could reveal any audible difference between the *Sonotone* "Velocitone Mark IV" and the most expensive magnetic cartridges. With its low mass and high compliance, this excellent cartridge can do justice to the finest high-fidelity music system.

The "Mark IV" is available in two versions. The Model 9TAF-SDHCV, which we tested, has a 0.7-mil diamond and a 3-mil sapphire stylus, in a replaceable turnover assembly, and sells for $20.25. The Model 9TAF-D77HCV has dual 0.7-mil diamonds, for doubled stylus life, and is priced at $24.25. Both prices include plug-in equalizers. ▲

"ROUND THE WORLD" TRIP

THE grand prize in International Rectifier's "Round the World" contest is a 28-day solo trip around the world or a 15-day trip for two to Europe. Electronic technicians are invited to get entry blanks at their local IR distributor. The contest, which opened on March 1st, closes on April 30, 1964. Details are available from the company's distributors. ▲

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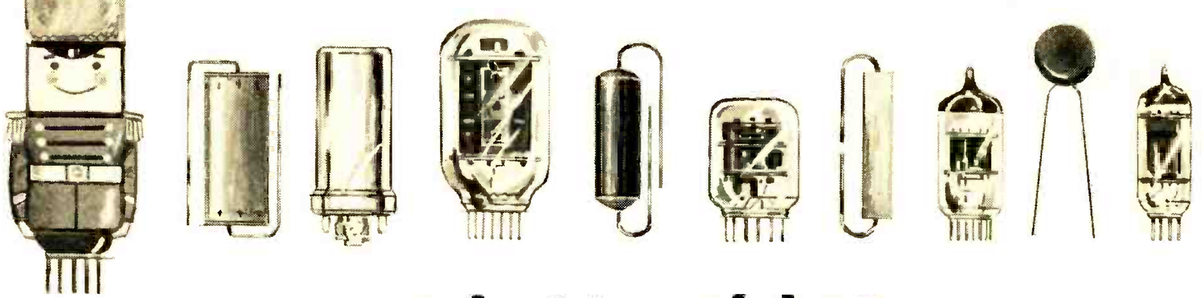

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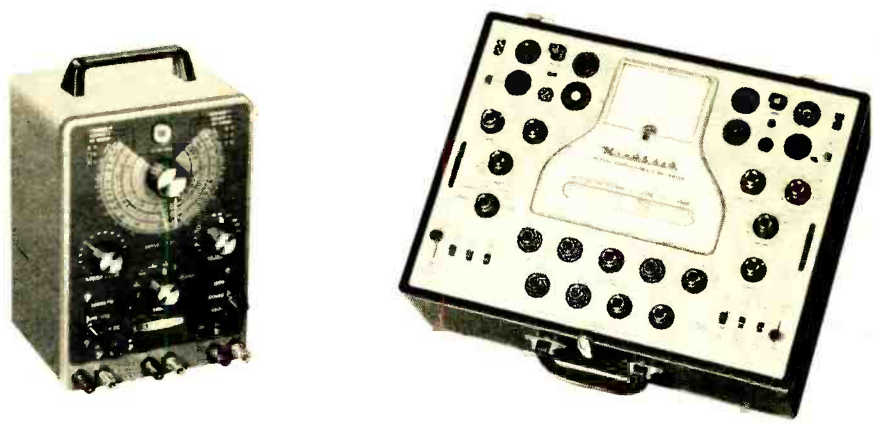

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SPECIFICATIONS—Test circuit: AC bridge, powered through special bridge transformer by an internal 60 cycle supply or by an external audio generator with 10 volts output. Upper frequency limit: 10 kc. **Capacitance, 4 ranges:** 10 uuf to .005 ufd; .001 ufd to .5 ufd; .1 ufd to 50 ufd; 20 ufd to 1000 ufd. **Capacitor leakage:** DC test voltages from 3 to 600 volts in 16 steps. **Resistance, 3 ranges:** 5 ohms to 5000 ohms; 500 ohms to 500 K ohms; 50 K ohms to 50 megohms. **Comparator circuit:** External standard R, L or C; Max. Ratio 25-1. **Power supply:** Transformer-operated, half-wave rectifier. **Power requirements:** 105-125 volts AC, 50/60 cycles, 30 watts. **Dimensions:** 9½" high x 6½" wide x 5" deep.

Kit IT-11 . . . 7 lbs. $29.95

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SPECIFICATIONS—Power requirements—Voltage: 105-125, 60 cycle AC. **Watts:** 10-60 (dependent upon tube under test). **Plate supply:** (SILICON RECTIFIERS). **DC volts:** 26, 90, 135, 225 + variable 80 to 200 (Separate DC supply for space charge grids). **AC volts:** 20, 45, 177. **Bias supply:** (SILICON RECTIFIER). **Low range:** 0 to negative 5 volts DC. **High range:** 0 to negative 20 volts DC. **Signal voltages:** 2, 1, .5, .25 volts AC 5000 cycles. **Filament supply voltage:** .65, 1.1, 1.5, 2, 2.5, 3.3, 5, 6.3, 7.5, 10, 13, 20, 27.7, 35, 47, 70 and 115. Currents: 300, 450, 600 ma. (Note: Filament voltage is reduced 10% during life test). **Testing circuits Gm:** (Mutual conductance-amplifiers) 0-24,000 micromhos. **Emission:** Rectifiers and diodes. **Leakage:** Direct reading ohmmeter. **Grid current:** ¼ microampere sensitivity. **Voltage regulators:** Firing voltage and regulation tolerance. **Low power thyratrons:** Grid characteristics, conduction capabilities. **Eye tubes:** Control grid characteristics. **Meter AC:** 1000 ohms/volt (1 volt full scale). **DC:** 89 ma full scale. **Scales:** Gm: 0-3000 micromhos. VR test volts: 0-200 volts. Leakage: 0-10 megohms. Diodes O.K. Rectifiers O.K. Line check arrow at midscale. **Tube complement:** (1) 3A4 oscillator, (1) 12AV6 meter control. **Calibration circuit:** Built-in switch operated. **Socket accommodations:** 4-pin, 5-pin, 6-pin, 7-pin combination and pilot light, 5 & 7-pin nuvistor, 7-pin miniature, 7-pin sub-miniature, 8-pin sub-miniature, octal, loctal, 9-pin miniature, 9-pin, Novar, ten-pin miniature, 12-pin Compactron. **Line voltage adjustment:** Continuously variable. **Roll chart mechanism:** Constant tension, free rolling, thumbwheel operated, illuminated. **Dimensions:** Cabinet (outside): 17¾" W x 13½" H x 8½" D. **Panel and chassis:** 17" W x 12¾" H x 5½" D.

Kit TT-1A . . . 34 lbs. $149.95

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TE-124

CIRCLE NO. 118 ON READER SERVICE PAGE

New FCC Rules

(Continued from page 30)

a desire to add this equipment to his line because of the ever-growing demand. Some u.h.f. equipment manufacturers are now furnishing equipment to other manufacturers for resale under a private-brand name.

The use of shared u.h.f. relay stations is also authorized. This means that a single relay station may be used by several licensees who share in the cost of maintenance and leasing or purchase of the equipment. By using tone squelch, use of the relay station by unauthorized stations is prohibited.

The 952-960-mc. microwave band is now available to Business Radio Service licensees, but only for control of base stations. Heretofore, the operation of private microwave systems by Business Radio Service licensees had been restricted to frequencies above 10,000 mc.

The rules, however, provide for operation of fixed point-to-point radio systems on the five business channels in the 27-mc. band just above the Citizens Band, on 80 channels in the 72-76-mc. band, on the low-power general purpose channels in the low, high, and u.h.f. mobile bands, and on the 49 Citizens channels in the u.h.f. band which are used primarily for business.

In the case of most land mobile services, radiotelephony using either AM or FM is normally authorized, but the rules state that other emissions may be authorized when the applicant makes a factual showing of need therefor. This implies that transmission of facsimile, data, teletypewriter, control, and telemeter signals may be authorized.

It is required that only type-accepted equipment be used in the land and marine mobile services, with the exception of Citizens class-D equipment. However, the rules state that transmitters operated at less than 200 milliwatts input need not meet FCC technical standards for type acceptance if they are adjusted so that the sum of the bandwidth occupancy plus frequency tolerance will not cause emission of signals more than 40 kc. removed from the assigned carrier frequency that are not attenuated at least 30 db. This means that some of the Part 15 (under 100-milliwatt) walkie-talkies may be used in licensed radio systems when AM is employed.

Operation of land mobile radio systems at airports on nine channels between 121.60 and 121.95 mc. is authorized. Such aeronautical utility stations must use AM and be employed only to meet the necessities of ground traffic control, and for communication with control towers, vehicles, and aircraft on the ground.

Use of SSB (single sideband) with reduced carrier on the marine frequencies between 1600 kc. and 30 mc. is now authorized as is the use of DSB with reduced carrier and the continued use of conventional DSB-AM (double-sideband AM). Private limited coast stations may be licensed to operate on 156.45 mc. using FM for communicating with boats. Eligibility is limited to operators of public moorage facilities and yacht clubs with mooring facilities.

Frequency tolerances are also tighter in some cases. Ship station transmitters must maintain 0.02% frequency stability in the 1600-2070 and 2080-3500-kc. ranges and 0.005% in the 2070-2080-kc. range. Land mobile frequency remains at 0.002% in the low band and 0.0005% in the high and u.h.f. bands except for transmitters operated at less than 3 watts input, and class-A Citizens stations. In the u.h.f. aviation band, frequency stability of land mobile units of less than 5-watt rating must be 0.01% and 0.002% for higher-powered units.

The new rules do not include the controversial Citizens Radio Service rule changes that were proposed. As of the December 21 version of the rules, there have not been many changes in CB rules except to reaffirm the purposes for which CB can be lawfully used. ▲

Frequency Tolerances in Percentages*

Frequency Range in Mc.	Less than 3 watts	3 to 300 watts	Over 300 watts	Citizens Bands
Below 25	0.02	0.01	0.005	-
25 - 50	0.005	0.002	0.002	0.005
50 - 1000	0.005	0.0005	0.0005	0.001**
1850 - 1990	0.02	0.02	18 watt limit	-
2110 - 2200	0.02	0.02	15 watt limit	-
2500 - 2700	0.02	0.02	12 watt limit	-
6525 - 6875	0.02	0.02	7 watt limit	-
12,200 - 12,700	0.05	0.05	5 watt limit	-

* Power is input to final r.f. amplifier.
** Except for class-B stations operating on 465 mc.

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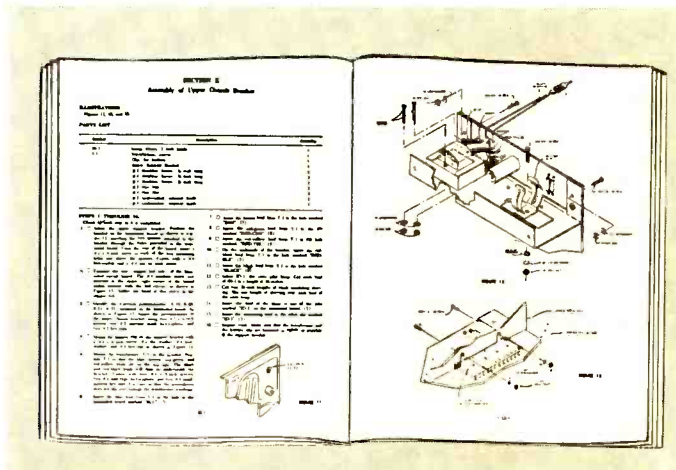
Ease of assembly is one thing. Parts are clearly identified. Each assembly diagram appears on the same page as the step-by-step instructions for that section of assembly. There's no need to refer back constantly to other pages, which consumes time and increases the chance of error.

Ease of alignment is another thing. Each kit contains complete instructions for accurate calibration or alignment of the instrument. Where necessary, precision calibrating resistors are provided for this purpose.

What does it mean? It means that with RCA kits you can get a professional V-O-M or VTVM for as little as $29.95*. Or you can get a good oscilloscope (one of the most useful—but normally one of the most expensive—test instruments) for only $79.50*

Specialized instruments such as an AC VTVM or an RF Signal Generator are also available as kits for far less than they would cost otherwise. In every case, RCA kits, when completed, are identical with RCA factory assembled instruments.



Each sub-assembly is described in a separate section with illustrations applying to that sub-assembly available at a glance. No cross referencing necessary.

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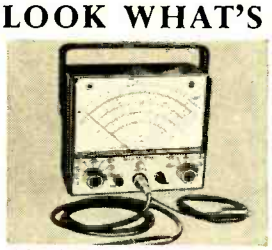
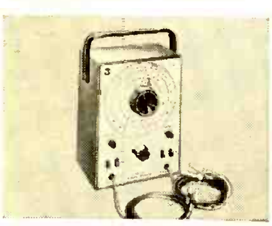


RCA SENIOR VOLTOHMYST. A professional VTVM. WV-98C(K). Kit price: $57.95*

RCA VOLT-OHM-MILLIAMMETER. One of most useful instruments. WV-38A(K). Kit price: $29.95*

RCA 3-INCH OSCILLOSCOPE. Compact, lightweight, portable. WO-33A(K). Kit price: $79.95*

RCA HIGH-SENSITIVITY AC VTVM. Doubles as audio pre-amplifier. WV-76A(K). Kit price: $57.95*



RCA RF SIGNAL GENERATOR. For audio and TV servicing. WR-50A(K). Kit price: $39.95*

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By R. L. WINKLEPLECK

One-transistor power supply delivers 15 watts over wide range of regulated output voltages.

SINCE the advent of power transistors, a number of circuits are available to convert low d.c. voltages to much higher levels.

Most of these circuits involve the use of multiple transistors in complex circuits. This supply's claim to fame lies in its simplicity, efficiency, and effective output voltage regulation. It is well suited for applications requiring only modest regulated power (since it uses only one transistor) and especially to those applications where the supply must be left on for long periods but power is drawn intermittently.

Under these conditions, the over-all efficiency increases considerably, making this unit ideal for use in a portable electronic photoflash, for a Geiger counter or megohmmeter, or for a small portable transceiver. It will supply almost fifteen watts of power at a wide range of regulated voltages. The complete converter is extremely small and can be built into a small package.

The circuit operates on the flyback principle similar to that used in a TV high-voltage system. As in the TV set, the transformer must have a special high-permeability core to reduce heating and increase efficiency. A small molybdenum Permalloy toroid is ideal for this purpose and you may save money by winding your own transformer.

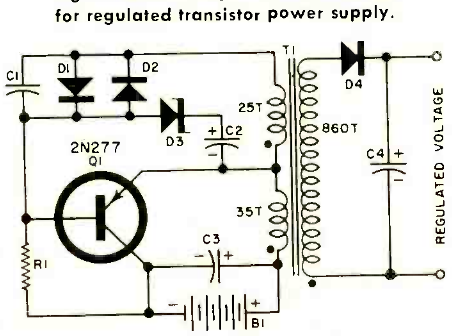
The basic pulsing of the transformer primary to produce high secondary pulses is well understood. But, let's follow the schematic to see how the regulation is achieved. When power is first applied to the circuit, the biasing effect of *R*1 and the leakage current through the transistor cause a positive voltage to be placed across the 35-turn transformer power winding and also across the 25-turn feedback winding. The dots on the schematic indicate the beginning of each winding. This produces a current flow through starting capacitor *C*1 which turns the transistor "on." Almost immediately, the voltage across *C*1 reaches the small starting voltage of diode *D*2 through which the bias current continues to flow. A silicon diode exhibits a high forward resistance until several millivolts are dropped across it. Then it conducts freely in what is considered a normal manner. During this "on" period, zener diode *D*3, the regulating diode, has a small reverse voltage across it equal to the transistor emitter-to-base voltage drop. *D*4 will also have a back voltage developed in the output winding of the transformer.

With both transistor junctions forward biased, the transistor is driven to saturation with current and voltage in the power winding rapidly climbing. The saturation limit of the transistor is quickly reached and as the transistor comes out of saturation, the current through the power winding levels off. The transistor base current decreases, causing the current through the power winding to decrease regeneratively, and the voltages across all windings drop to zero.

At this point, the energy stored in the core is released in a flyback action, the voltages across the windings reverse and the transistor is completely cut off. The reversing voltage makes *D*4 conductive and the energy stored in the transformer is, during the flyback period, transferred to *C*4. When the current in the output winding falls to zero, there is no longer any reverse voltage to hold the transistor "off" and the cycle repeats.

During the first few flyback pulses, the voltage across *C*4 climbs rapidly, but thereafter it changes only slightly with each pulse. The flyback current through the transformer output winding decays more slowly as the charge on *C*4 rises. During each flyback interval, regulator capacitor *C*2 is charged through *D*1 and *D*3 to a voltage bearing approximately the same ratio to the voltage on *C*4 as the ratio of the two transformer windings. Eventually, *C*2 becomes charged to a level greater than the zener voltage of *D*3. When this happens and the next "on" period is ready to start, *C*2 discharges through *D*3 holding the transistor base positive and keeping it cut off. This back bias is less than one-half volt and there is virtually no conduction through either *D*1 or *D*2 but it slowly discharges through *R*1, the battery, and the power winding. Soon it is no longer great enough to prevent the resumption of oscillations and the transistor cycles a few more times to bring the voltage on *C*2 (and also on *C*4) back up to cut-off level.

Fig. 1. Circuit diagram and parts list for regulated transistor power supply.



R1—47,000 ohm, ½ w. res.
C1—.02 µf., 100 v., tubular capacitor
C2—25 µf., 25 v., elec. capacitor
C3—100 µf., 25 v., elec. capacitor
C4—Low-leakage, high-value elec. capacitor (see text)
D1,D2—200 p.i.v. silicon rectifier (TI 1N2069 or equiv.)
D3—Zener diode (see text)
D4—600 p.i.v. silicon rectifier (TI 1N2071 or equiv.)
Q1—2N277 power transistor
T1—Special toroid transformer (see text)
B1—4- to 6-v. battery

Thus regulation of the voltage across load capacitor *C*4 is achieved with a variation or swing of five to ten volts. Maximum efficiency is realized when *C*4 has high capacitance and low leakage. As a matter of fact, *C*4 must have a capacitance of several hundred microfarads to give really effective regulation. A photoflash capacitor, such as the 525 µf., 450-volt, *C-D* FWSN10001, is excellent for *C*4 even though the supply is not being used in a photoflash unit.

It is obvious that the level of the regulated voltage is determined by the zener voltage rating of *D*3. A 5.6-volt zener in this circuit with a 5- to 6-volt supply will produce a regulated output of 290 to 300 volts. A ten-volt zener will produce 485 to 495 volts regulated. As a rough rule of thumb, select a zener diode with a voltage rating one-fiftieth of the desired output voltage. This is only approximate and is also subject to the error introduced by the 5 or 10% tolerance of the zener diode. It does, however, indicate the approximate value of the zener diode required. Since the secondary pulses have an extremely high peak, it is possible to achieve good regulation by correct zener diode selection over a very wide output range.

This circuit will provide regulation up to or slightly beyond a fifteen-watt output. Thus, at a regulated 250-volt output, as much as 60 ma. can be drawn without causing any voltage variation. At 500 volts, 30 ma. can be drawn and still maintain regulation.

The supply draws five to six amperes from a 5- to 6-volt supply and operating efficiency is slightly over 50%. Other converter circuits will exceed this efficiency under steady-state conditions but the "on-off" feature of the regulation makes this circuit very attractive, when used intermittently.

There are a number of modifications to the basic circuit that offer opportunities for other applications. For example, if a 1-µf. capacitor is substituted for *C*4 and a .5 µf. for *C*2, the degree of regulation is reduced to virtually nothing, but more of the voltage of the sharp output peaks can be captured. A two-volt input at about 800 ma. will charge *C*4 to one thousand volts and this is by no means the upper limit. The transformer itself is suitable for use in a high-voltage power supply based on the Hartley oscillator circuit. By eliminating $D1$, $D2$, and $D3$, and $C2$ and by substituting a CK722 for the power transistor and a 0.1-μf. capacitor for $C4$, we have a Hartley oscillator power supply. It will produce 200 volts open circuit with a 9-volt, 7-ma. input. These are not the best choices for $C1$ and $R1$ to achieve maximum efficiency but are indicative of the possibilities.

$C3$ is needed only when the IR drop in the battery is great enough to warrant levelling out the current demand.

The transformer core is a small doughnut-shaped toroid one-inch across and with a small hole 0.58-inch in diameter. It is manufactured by *Arnold Engineering Corp.* as A-930157-2. The output winding is applied first and consists of 860 turns of #35 Formvar or enamelled wire. This is the only hard part of the job as the other two windings are much smaller.

The output winding requires about 107 feet of #35 wire, which is first wound on a small bobbin then repeatedly threaded through the core hole. The wire should be evenly spaced around the core ending with the 860th turn back at the starting point. Attach color-coded insulated leads and apply a *thin* layer of plastic tape.

The feedback or regulator winding is applied next in the same manner. About 4½ feet of #30 wire will be required for the 25 turns. The heavy power winding goes on last, again with a layer of tape between the two windings. The 35 turns of #18 wire will require about 8 feet of wire. The short power and feedback windings are quite easy to apply. Be sure that each winding is evenly spaced around the core, that they are all wound in the same direction, and that they are insulated from each other.

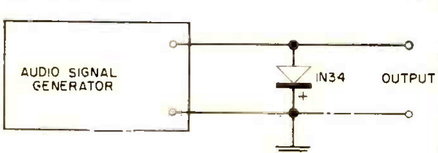
The toroid core is available from the *Dao Corp.*, P.O. Box 659, Terre Haute, Indiana, for $1.50 postpaid. The complete transformer may be bought from the same source for $12.50 postpaid. ▲

VERY-LOW R.F. SIGNALS

By THOMAS R. HASKETT

MOST r.f. signal generators don't go below about 250 kc., and if it is necessary to generate signals in the region from 20 kc. to 250 kc., "subharmonics" can hardly be used—but harmonics can.

It is only necessary to connect a crystal diode across the output of an a.f. signal generator, as shown. "Mixing" action will produce harmonics up to the 5th and even (weakly) the 10th. The range is therefore extended to cover low i.f. alignment or supersonic remote-control devices. ▲



NEW CIRCUITS FOR FM PORTABLES

AT the present time, there are quite a number of transistor FM portables on the market. Important differences among them are the circuit innovations that distinguish one maker's set from another. One example of these new FM portables is the model 12TC666, made by *Toshiba.*

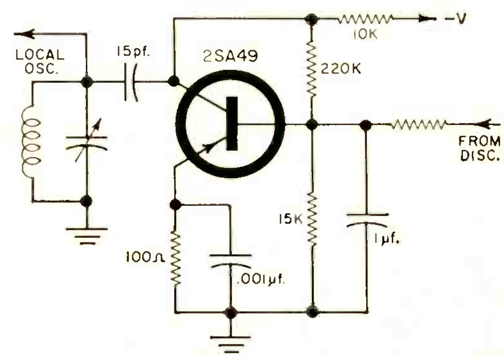
Most FM portables have been using some form of variable-capacitance diode circuit controlled by the detected signal voltage to control the local oscillator frequency. *Toshiba,* on the other hand, is using a transistor circuit (A) that is said to be more sensitive than the diode circuit.

With the transistor connected across the oscillator tank circuit, when the received frequency shifts, the output from the FM detector varies the operating current of the a.f.c. transistor thereby changing the capacitance between the collector and the base. This causes the local oscillator frequency to shift to center the i.f. to the detector bandpass frequency.

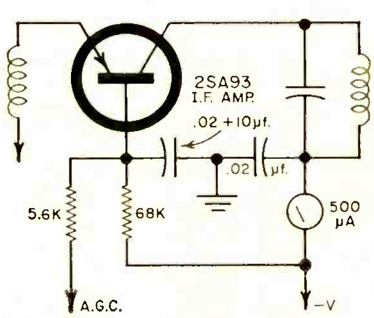
Another circuit addition is the use of a sensitive tuning meter. This meter (B) is located in the collector circuit of the a.g.c.-controlled i.f. amplifier. When the signal comes in and the a.g.c. starts to work, the collector current decreases and the meter deflection goes to a minimum. Minimum collector current indicates proper tuning.

The audio output stage of this receiver also shows some design innovations. The basic arrangement is quite ordinary with an audio preamplifier feeding a driver stage which, in turn, operates a two-transistor, class-B output stage.

Because class-B output stages have some crossover distortion, and also because the frequency response of the small loudspeakers usually used in portables is poor at both low and high frequencies, a double negative-feedback system is used. One loop goes from the driver stage back to the preamplifier while the other goes from the speaker voice coil back to the preamplifier. This latter loop is arranged to have a 2 to 3 db peak at approximately 100 cps. This has been done because it has been found that the small speaker used sounds better with this peak. ▲

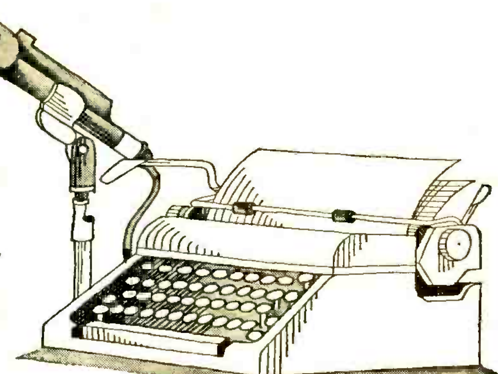


(A)



(B)

RADIO & TV NEWS



EVERY month sees another increase in the amount of information to be transmitted over existing microwave communications systems. These systems, especially in metropolitan areas, are becoming saturated with traffic and have almost hit their operating limits. Many people look to the laser with its enormous bandwidth to carry the large future loads. Such laser systems are still in the laboratory stage.

According to Dr. Gerhard Weibel, of the *General Telephone and Electronics Lab.*, there is no reason why millimeter waves couldn't be put to work. A single millimeter channel has a greater capacity than a microwave channel yet is not affected by weather conditions to the same degree as a laser beam. Theoretically, a millimeter-wave system could carry about 10,000 or so voice channels, or about 10 times more than the present operating capacity of a microwave system. Even more important, an extremely large number of millimeter-wave systems could be operated in the same area and in many cases on the same frequency without mutual interference. This is due to the narrow antenna beamwidths possible at the higher frequencies.

Dr. Weibel also pointed out that millimeter-wave units could be placed only a few miles apart compared with the 25 to 40 miles of microwave systems. In such short-hop systems, towers could be close enough to penetrate the atmosphere in bad weather, and the equipment could be relatively inexpensive, low-power, solid-state types.

Electronic Bloodhound

One of the problems with certain types of toxic gases is that by the time you smell them, it may be too late to do anything about it. *Honeywell* has come up with an electronic device capable of detecting an odor of one part in a million parts of air, and when gas level exceeds a preset level, sounds an alarm.

The unit can detect many varied gases such as gasoline, paint, lacquer, ammonia, styrene, tear gas, many acids, and even ripe apples and bananas. First use will be for detection of perchlorethylene, a toxic gas used in dry-cleaning establishments.

The device is based on the principle that some gases absorb ultraviolet radiation more than others. A sample of suspect air is passed between the ultraviolet source and a special detector tube. If the air contains some of these gases, part of the ultraviolet radiation is absorbed, cutting down the amount picked up by the detector and triggering a relay to turn on the alarm or start ventilation fans.

Besides the keen nose, the device also resembles a bloodhound because the fan which pulls in the air acts like the long ears that the bloodhound uses to funnel the scent to his nose. However, this device can't wag its tail.

Integrated Hearing Aids

For quite some time now, we have been talking about integrated circuits and when they would make their debut in consumer products. Well, it has happened.

At the recent IEEE meeting, a new integrated six-transistor audio amplifier, developed by *Zenith* and *Texas Instruments, Inc.*, and proposed for use in the latest *Zenith* hearing aids, was demonstrated.

This circuit is so small that 10 of them can be stacked in a space the size of the head of a kitchen match. Necessary external items consist of a microphone, earphone, and battery. An effort is being made to reduce the size of these components.

Although the new device is somewhat more expensive than the conventional hearing aid, it is expected that the integrated device will become an important part of *Zenith's* hearing aid business.

Patrick E. Haggerty, president of *Texas Instruments, Inc.*, said that this is the first time that such circuits have been used in consumer products. Similar units have been used in earth satellites. Haggerty went on to say ". . . what we have here is a semiconductor circuit built by transistor techniques as a single part, rather than an assembly of 22 parts, each linked to each other. Electronic systems built this way offer a reliability improvement factor of 5 to 1 over comparable systems built with conventional components." ▲

Light Dimmers

(Continued from page 29)

2. Electronic cut-offs or "trips" which open the circuits and cause the SCR's to block completely on application of overloads at any time.

3. Circuit breakers in conjunction with phase-back and/or choke circuits to open the load circuits.

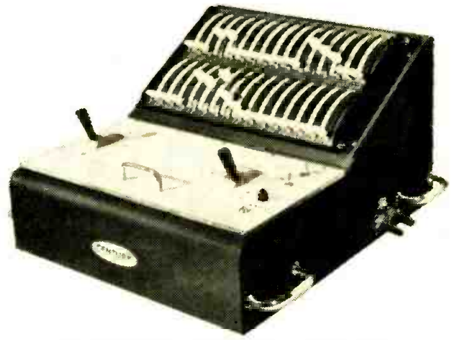
4. Quick acting fuses which have current-time constants less than those of the controlled rectifiers.

5. Derating of the SCR's and other components subject to failure on overloading.

All of these methods are used. Phasing back is good, but there is no such thing as a sharply breaking curve which will permit unlimited passage of currents right up to rating and then immediately limit beyond that point. Alone, they do not open the circuit, but permit faults or overloads to continue. The electronic trip circuit requires a fuse to protect components on direct short circuits. Chokes add weight to a dimmer and also cause voltage drops which must be considered or compensated for in the over-all system design. The time constant of a fuse is seldom related to its current-carrying capacity and matched to a given controlled rectifier. Hence, we find that a fuse which will just protect a rectifier often will not carry the normal load of which the rectifier is capable. If we fuse the rectifier for its load, it may destroy itself before the fuse opens on a sudden overload. Most systems use combinations of two or more of these methods of protection.

Console and portions of the preset panels used for control of electronic (thyratron) dimmers at the U.S. Building, Brussels World's Fair. This was a 72-circuit, 10-scene preset system.

The author is more familiar with large systems than with small individual controls. He also realizes that the latter will provide demands for equipment a thousandfold greater than those of the high-powered specialized devices. But it is the unusual and specialized applications that stimulate development and provide the greater interest and problems leading to unique solutions. One day variable control over the intensities of our lighting circuits may be as common as wall switches are now. The theater has already passed this stage. Common "on-off" circuits as compared to "dimmers" in modern lighting control systems in the theater are in the ratio of one to twenty or greater.



A 15-circuit two-scene preset portable control console for an electronic dimmer system. Two large controls are scene masters, interlocked to provide for scene-to-scene fading.

A new problem is arising in the design of these systems. The number of control circuits and their presets are becoming just too much for one or even a crew of operators to handle properly. Pilot controls have reduced the size of the control consoles; but what is to be done with a hundred control circuits in ten or more presets or cues—a thousand individual controllers which must be reset many times during the course of a single presentation?

Formerly the size and weight of the dimmers themselves were the restricting elements in a control system design. Now the pilot control center is the stumbling block. Should we go to automated controls where the various dimmer readings or cues are translated to tape or cards? Or should other "memories" be considered so that a single controller can be transferred from circuit to circuit? The only sure answer to the questions—"what" and "how"—a year from now will be—"differently from today." ▲

This silicon controlled rectifier dimmer bank contains 45 plug-in units with capacities ranging from 2.5 to 12 kw. Integral fans draw air through grilles for cooling SCR's.

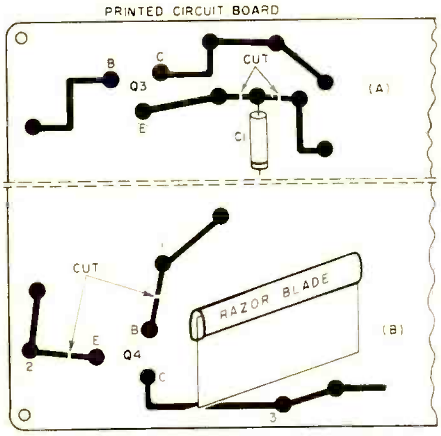


Fig. 1. (A) Isolating a component from circuit. (B) How to isolate a transistor.

PRINTED BOARD REPAIR

BY GLEN McKINNEY

SINCE practically all transistorized equipment uses printed circuit boards for mounting parts and for lead connections, it sometimes becomes a major problem to trace a particular circuit or check a suspected part for an open or short. A certain conductive lead may have several components joined to it at different points, making it difficult to isolate a particular part of the circuit without considering the complete circuit as a whole. Consequently, misleading interpretations can arise when making voltage and resistance measurements. Fortunately, most parts are mounted on one side of the board, leaving the other side with only the conductive leads exposed for testing.

Fig. 1 illustrates a method which is quite practical for troubleshooting to isolate suspected components without having to remove one end of the component for a direct check. This procedure is quite simple and fast, and the odds are much less that the component will not be disturbed at all. A razor blade or other sharp knife-edged tool is used to cut the conducting material at the proper point near the suspected part. Be sure the tool is sharp enough to *cut* the material and not tear it. A neat slit is all that's necessary, and it may be bridged easily with solder after the repair is made. The lead may be cut on both sides of a component when necessary, leaving it completely free from the rest of the circuit for testing.

When the lead is cut, it is good practice to check across the gap with an ohmmeter to make certain the lead is completely open. ▲

Voltage Regulator Design

(*Continued from page* 54)

keep the load voltage constant. This action is the same as that described for the VR-tube regulator. While the regulating action of the zener and the VR tube is very similar, the manner in which this action is accomplished in the zener is quite different.

Zener Regulator Design

Simple zener regulators like that of Fig. 4 are easy to design. The procedure is the same as that for VR-tube regulators with heavy loads. Special precautions must be taken with zeners, however, since they are quite temperature sensitive.

As in VR-tube regulator design, the basic problem is to calculate the value of $R1$ for known values of supply voltage, load current, and load voltage.

We can use the formula given previously (2), but the terms are changed to represent zener rather than VR-tube voltage and current. The formula is:

$$R1 = \frac{E_S - E_Z}{I_L + I_Z} \qquad (3)$$

I_Z is generally made equal to 10% of the desired load current, so the formula can be rewritten as:

$$R1 = \frac{E_S - E_Z}{I_L + .1\ I_L} \qquad (4)$$

In this formula, E_S is the minimum supply voltage expected under maximum load conditions. E_Z is the desired zener and load voltage, and I_L is the maximum expected load current.

After the value of $R1$ is calculated, the power handling capabilities of the zener must be determined. The formula below will enable you to do this.

$$P_Z = \left(\frac{E_S - E_Z}{R1} - I_L \right) E_Z$$

E_S in this formula is the maximum value expected while the others are the same as described previously.

To demonstrate how to use these formulas, let's work a problem.

Problem: Assume that we need to regulate the supply voltage to a transistor amplifier that requires 10 volts at 20 ma. for proper operation. An unregulated 15-volt supply is available.

Solution: The problem is to find $R1$ and the power ratings of $R1$ and the zener. $R1$ is found by inserting the known quantities into our formula. Assume that we have found, as before, that the unregulated supply voltage drops to 12 volts under maximum load.

$$R1 = \frac{12 - 10}{.02 + .1(.02)} = \frac{2}{.02 + .002}$$

$$R1 = \frac{2}{.022} = 91 \text{ ohms}$$

The power rating of the resistor is found as before:

$$P = I^2 R$$

$$P = (.022)^2 91 = .000484(91) = .044 \text{ watt}$$

A standard ¼- or ½-watt resistor would be more than sufficient.

The zener power rating is now found.

$$P_Z = \left(\frac{15 - 10}{91} - .02 \right) 10$$

$$P_Z = \left(\frac{5}{91} - .02 \right) 10 = (.055 - .02)\ 10$$

$$P_Z = (.035)\ 10 = .35 \text{ watt}$$

Once the calculations have been made, the zener can be selected. Unlike VR tubes, zener diodes are available in a wide range of voltages. Almost any value between 3 volts and 200 volts can be obtained with tolerances of 5%, 10%, and 20%. Power ratings of .4, 1, 3.5, 10, and 50 watts are common. For this problem, a .4-watt zener would probably suffice, but for an extra-wide margin of safety, a 1-watt unit should be used. It is always wise to use a higher power zener than is necessary to avoid overheating troubles.

The above procedure will cover most cases of zener regulator design. One special case should be considered. If the load should become disconnected (load current zero), the zener current will rise considerably. If the power rating of the zener is not sufficiently high, it may be destroyed by overheating. This condition should be anticipated and compensated for. This is done by simply using a zero for I_L in calculating the zener power rating (P_Z). The zener selected on the basis of this power calculation will have a rating high enough to stand the no-load/high-current condition. (If this is done in the previous calculation, the zener diode power rating comes out to .55 watt. The use of a 1-watt zener would provide adequate safety factor.)

Zener diodes can be connected in series just like VR tubes to obtain a higher regulating voltage. It is not necessary for the individual zener voltages to be equal just as long as their power ratings are similar. The design procedure is the same, except for E_Z in the formulas use the sum of the individual zener voltages.

From what has been said previously it is evident that zener diodes have numerous advantages over VR tubes. The most apparent is the fact that zeners are available in a wider range of voltage ratings than VR tubes. In addition, the supply voltage for a zener regulator need only be several volts more than the zener rating while for VR tubes the supply voltage must generally be 20% or 30% higher than the VR-tube rating. Other advantages of the zener over the VR tube are its small size, ruggedness, longer life, and greater reliability. The VR tube has greater initial drift when voltage is first applied to the circuit than the zener and its operation may be somewhat erratic.

The greatest advantage of the VR tube is its low cost. Zener diodes are still quite expensive and until their cost is lowered, VR tubes will continue to be popular in many applications.

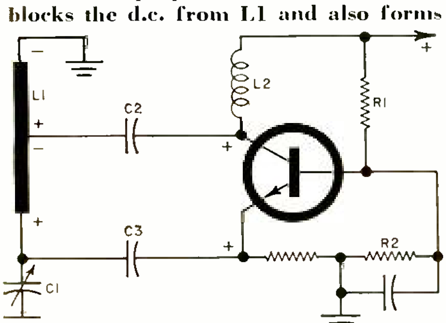
Both the VR tube and zener regulator provide a certain amount of filtering. Since they oppose current and voltage variations in the supply, they will also oppose and minimize ripple from the supply. This is especially true of the zener since its internal impedance is very low (much lower than that of a VR tube). The very low impedance of the zener makes it react much the same as a large filter capacitor to the a.c. ripple.

Random noise is produced to some extent in both VR tubes and zeners and can be troublesome in some cases. It can usually be eliminated or minimized considerably by adding a small capacitor in parallel with the VR tube or zener. A value between .01 and .1 μf. is generally suitable for zener diodes, but the exact value for VR tubes should be determined experimentally since some values of capacitance will cause the VR tube to go into undesired oscillation. ▲

U.H.F.-TV OSCILLATOR

U.H.F. conversion in the new line of G-E TV receivers is accomplished by an all-solid-state u.h.f. converter. A unique feature of this converter is the local oscillator whose partial schematic is shown. The "n-p-n" diffused silicon transistor is used in a modified Colpitts oscillator with a common-base configuration.

Oscillator inductance L1 is tuned by C1, a section of a three-gang tuning capacitor. The collector is tapped down on L1 for a proper impedance match. C2 blocks the d.c. from L1 and also forms



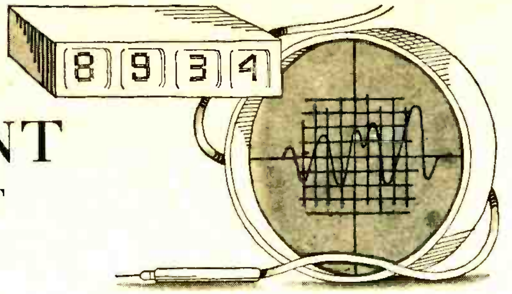
part of the feedback circuit. L1 is also connected to the emitter by C3 which is part of the feedback circuit.

L1 can be considered as an autotransformer as far as feedback is concerned, with the polarities shown for a given half-cycle of the sine wave. Since there is no phase inversion between emitter and collector, the polarities on the autotransformer are correct to produce feedback without phase inversion.

L1 is inductively coupled to the mixer for oscillator injection.

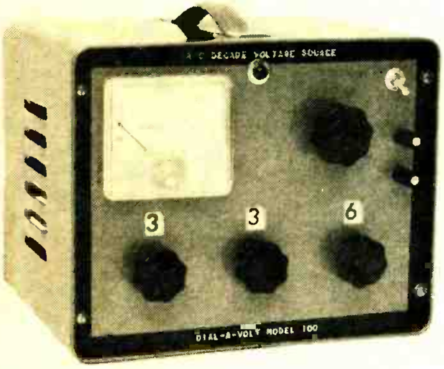
The 10-v. supply is divided by R1 and R2 to provide the proper base bias and L2 serves to isolate the collector from the power supply so that it will be above ground for r.f. ▲

TEST EQUIPMENT
PRODUCT REPORT



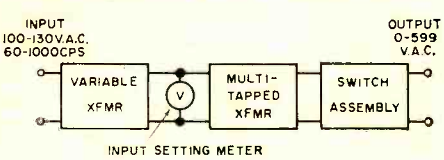
Idalee Model 100 A.C. Decade Voltage Source

For copy of manufacturer's brochure, circle No. 44 on coupon (page 15).



IN many of the testing procedures encountered in the laboratory, factory, and service shop there is a need for an accurate, variable source of a.c. voltage. Meter calibration, bridge nulling, transformer, relay and motor testing, and comparison between a standard and unknown are a few of the tasks that demand precisely known voltages. The common method for obtaining these voltages is by means of a variable transformer, used in conjunction with a meter to indicate the various voltage levels. However, accurate meters are expensive and delicate, and the need for making repeated adjustments of voltages against meter readings is time-consuming and tedious. In addition, even with expensive meters it is difficult to detect a one-volt difference in several hundred volts.

The "Dial-A-Volt" a.c. decade voltage source, manufactured by *Idalee Electronics Corp.*, provides a.c. voltages in precise one-volt increments by a simple switching procedure, in much the same way as the familiar decade resistance box provides known values of resistance. No external reference meter is required. The operator merely turns three knobs to set the voltage desired in units, tens, and hundreds of volts. Operating directly from the 117-volt a.c. line, the unit provides outputs from 0 to 599 volts, with an accuracy of plus or minus 0.5% at any output. This output is clearly indicated in windows above the switch knobs. To obtain any other voltage requires only the dialing of the decade switches to the new value desired.



The operating principle can be seen from the block diagram. Input voltages from the line are fed into a variable transformer, which is adjustable by means of a front-panel knob. This variable transformer is used to normalize the input to a particular reference voltage (indicated on the expanded-scale panel meter), which is then fed into the tapped transformer primary. The instrument can be used with any line voltage from 100 to 130 volts. The precisely engineered multi-tapped transformer provides the desired output voltages, as determined by the positions of the three decade switches.

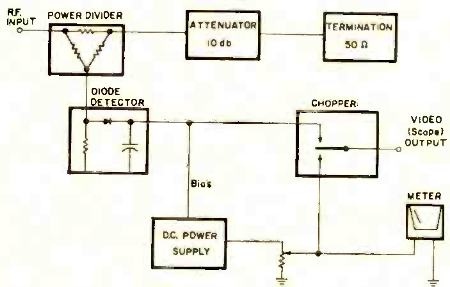
The Model 100 operates at any frequency from 60 cps to 1000 cps, making it readily applicable to both industrial and military testing requirements. For safety and to prevent undesired circuit interaction, the output of the instrument is isolated from both the input and from ground.

The Model 100 is available in a number of special types to suit particular needs. Price is in the $300 to $400 range, depending upon the combination of features desired. ▲

Boonton 8900B Peak-Power Calibrator

For copy of manufacturer's brochure, circle No. 45 on coupon (page 15).

TODAY there are a great many electronic systems that use pulsed r.f. signals. These include radar, air navigation, telemetry, communications, command and control, and radiosonde. A need exists for a device that is able to measure accurately and easily the peak power of the r.f. pulses used in such systems. The *Boonton* 8900B is such a unit. It is able to measure the peak r.f. power of pulses in the range from 150 to 1500 mc. The power level is read out directly on the panel meter and is completely independent of repetition rate and pulse width. A maximum peak power of 200 mw. is indicated on the meter, but this can be readily increased with external attenuators.

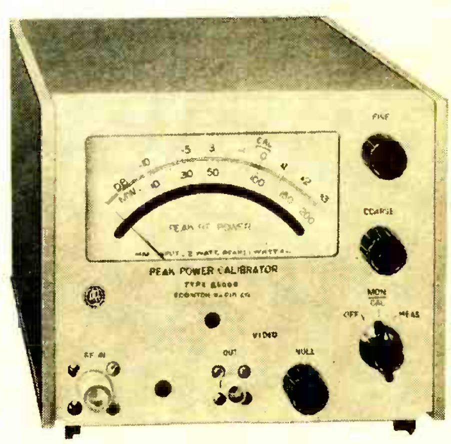


The peak power measured is actually the average power that would exist if the pulsed source were left on all the time. It is *not* the instantaneous peak power or envelope peak power that exists at the peak of the r.f. voltage waveform. Assuming a sine-wave c.w. source with an average power of 1 watt, the peak power rating is also 1 watt. If the source is turned off 50 percent of the time, the average power will be ½ watt, whereas the peak power rating remains 1 watt.

Referring to the block diagram, note that the signal is sent through two paths by virtue of the power divider. In one path, the signal passes through an attenuator and is absorbed in a 50-ohm load. In the other path, the signal is applied to a special diode peak detector which develops a d.c. level equal to the peak voltage of the r.f. waveform. The diode is forward-biased to bring it to an operating point of maximum stability and to get away from the square-law region of its curve into the linear portion.

As the diagram indicates, a variable d.c. supply is also included. The output of the supply is connected to a d.c. meter, which monitors its voltage, and to one leg of a mechanical chopper. If the chopper is set in operation and its selecting arm is connected to an oscilloscope, one can look first at the d.c. level produced by the peak detector in response to the pulsed r.f. voltage, and then at the d.c. level from the variable supply.

In operation, the supply is adjusted until the two voltages are exactly equal.



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City ____________ Zone ________ State ________

SORRY—No charges or C.O.D. orders! EW-54

The d.c. meter monitoring the output of the variable supply has been calibrated in terms of r.f. level required to produce a given d.c. from the peak detector. Hence, peak r.f. power can be read from it directly. The c.w. power is also correctly indicated since the calibration is in terms of the peak voltage waveform.

The detector output is also available directly through a two-stage emitter-follower for pulse monitoring. By replacing the 50-ohm termination with an accurate bolometer or calorimeter and applying a c.w. source, the instrument can be readily standardized.

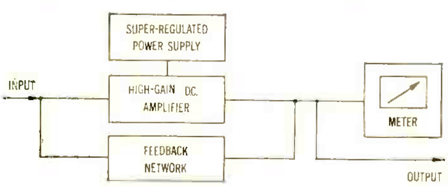
The Model 8900B is housed in a modular cabinet which can be rack-mounted, if desired. Price of the unit is $485. ▲

Keithley 409 Picoammeter

For copy of manufacturer's brochure, circle No. 46 on coupon (page 15).

THE new *Keithley* Model 409 picoammeter will sense currents at the extremely low value of 0.03 picoampere in circuits with a least a 1-volt source. (One picoampere or 1 micro-microampere is 1 millionth of a millionth of an ampere.) Typical applications include measuring leakage currents in solid-state devices, determining capacitor leakage resistance, amplifying and measuring signals from ion gauges, liquid-level gauges, thickness gauges, phototubes, and mass spectrometers.

The instrument has twenty d.c. current ranges with full-scale readings of 1 milliampere all the way down to 0.3 picoampere. A single electrometer tube is used at the input while the remainder of the circuit is all solid-state, including the power supply. This supply furnishes a 15-volt output to the d.c. amplifier (see block diagram) and is super-regulated. The output varies less than 0.001% for 10% line-voltage changes, and it has a long-term stability within 0.1%.



The high-gain d.c. amplifier utilizes a single electrometer-tube input, an emitter-follower isolating stage, two solid-state voltage-amplifier stages, and an emitter-follower output stage. The first emitter-follower and the first voltage-amplifier stage are temperature compensated by use of two identical silicon transistors. The d.c. amplifier and range-selector switch are enclosed in a housing which shields them against stray magnetic and electrostatic fields. This design limits output noise to less than 1% r.m.s. of full-scale on any range.

The use of negative feedback across the d.c. amplifier gives the instrument a fast speed of response. The feedback also reduces the input voltage drop to less than one millivolt and the input resistance to 1/1000 or less of the value of the source resistance.

The company manufactures a complete line of picoammeters with various ranges and characteristics. The Model 409 is priced at $525. ▲

New CB Circuits

(*Continued from page 47*)

Fig. 2. It is a plug-in unit, permitting a choice of up to 10 different frequencies spotted throughout the audio range. When the circuit is in the receive mode, incoming receiver audio is amplified by *V1* and *V2A*. If the tone is on the correct frequency it resonates in the tone filter. Larger voltages appear across the inductor. From pin 6 on the filter, signal is rectified and serves to operate control tube *V2B*. The CB operator is made aware of an incoming call as relay *RL* illuminates a message light and completes the circuit to the loudspeaker in the unit.

Generating the "ring" tone for transmit is accomplished with several of the same components. When *S1A* at the left is depressed by the operator, circuit reconnections create a feedback path from the tone filter (pin 6) to the input of tube *V1*. Sustained audio oscillation results, determined by the *LC* constants of the tone filter.

If the "*Q*" of the tone filter is compared to that of a typical reed relay the difference is considerable. Reeds are capable of "*Q*" well in excess of 1000; the *LC* circuit here is rated at approximately 100. And to attain the relatively high "*Q*" of 100 for a tuned circuit on audio frequencies, *Polytronics* employs special components—a ferrox cup-core inductor and high-"*Q*" capacitor. The relative broadness of the tone filter, however, is intentional. The circuit is less susceptible to temperature and other variations which tend to produce mistuning and missed calls. The company also feels that the elimination of vibrating contacts greatly extends the operating life of the device. ▲

REFERENCES

1. Mark Products, 1801 W. Belle Plaine Ave., Chicago 13, Ill.
2. Polytronics Labs., 88 Clinton Rd., West Caldwell, N.J.

Mike Sensitivity Rating

(*Continued from page* 31)

the voltage output for various sensitivities and impedances is given here. Note that for the example just considered, the voltage is 16 db above 1 mv. (about 6.32 mv.) with load, and 22 db above 1 mv. (about 12.6 mv.) open-circuited.

High-Impedance Mikes

In rating high-impedance microphones, we are not interested in changing the impedance of the microphone and, therefore, the sensitivity is given as an open-circuit voltage output for a sound-pressure input. For example, a high-impedance microphone with a sensitivity of -55 db re 1 volt/dyne/cm.^{2} will produce an open-circuit voltage of .0018 volt (1.8 mv.) with a sound-pressure input of 1 dyne/cm.^{2}

The microphone sensitivity rating determines the voltage output at only one sound pressure. However, since nearly all microphones are linear over all pressures to which the microphone is exposed, the voltage output is a direct function of the sound-pressure input. If the sound-pressure input is increased by a factor of 10, for example, then the microphone output voltage is increased by a factor of 10. Thus, if the sensitivity is known and the sound pressure is known, then the microphone output voltage is determined.

Sound Pressures

Microphone sensitivity ratings are used to determine the required amplifier input characteristics. From the above discussion, it can be seen that with the sensitivity known, the range of microphone output voltages then depends directly upon the range of sound-pressure inputs.

Sound pressure values are usually given in db referenced to .0002 dyne/cm.^{2} This value is considered to be 0 db sound pressure and is approximately equal to the threshold of hearing. Some typical values of sound pressure that indicate the range of sound pressures that may be encountered are as follows: the r.m.s. value of speech at ¼ inch is approximately 107 db (44 dynes/cm.^{2}) with peaks exceeding this value by 12 db; average total pressure of a 15-piece orchestra at 10 feet equals 72 db (0.8 dyne/cm.^{2}) with peaks exceeding this value by 20 db*; threshold of pain, 130 db (640 dynes/cm.^{2}); acoustic noise level in a very quiet studio, 10 db° (0.0006 dyne/cm.^{2}). Thus, it can be seen that the first amplifier stage may be required to operate over an extremely wide range of input voltages. ▲

°Olson, H. F.: "Acoustical Engineering," D. Van Nostrand Company, Inc., 1957.

Electronic Tachometers
(*Continued from page* 35)

portion of the applied pulse waveform.

Transistor output, across *R*4, is a negative-going waveform of approximately square shape, which is differentiated by capacitor *C*2 into a pair of spikes. Diode *D*3 shunts the positive-going spikes to ground, while *D*4 removes what remains of the positive-going waveform and passes the negative-going spike to the meter.

Since the time constant through *C*2 and *D*3's reverse resistance remains the same at all times, pulse width to the meter is constant. Regulation of transistor collector voltage by zener diode *D*2 holds pulse amplitude constant. Thus each spike applied to the meter will be of constant energy content and the meter will mechanically integrate these pulses, as explained before for the relay circuit. Calibration control *R*5 adjusts meter sensitivity so that the dial reading may be corrected; since the scale is linear, one-point calibration suffices.

The circuits used in the accessory-manufacturers' tachometers are apparently similar to that of Fig. 2, although at least one has reduced the semiconductor requirement to one transistor and one diode. This may be done in the circuit of Fig. 2 by moving the zener diode, *D*2, to the position occupied by *D*3 and allowing the base-emitter junction of the transistor to replace *D*1. With the zener across the meter, *D*4 may be omitted.

More elaborate circuits than these have been published in the past. One, in particular, made use of a monostable multivibrator designed around two silicon transistors to deliver a standardized output pulse for every ignition pulse received, in an effort to improve accuracy. Also, more elaborate circuits employ some type of temperature compensation to prevent possible calibration changes with temperature.

Note that the circuit in Fig. 2 uses an *n-p-n* transistor for negative-ground autos; for positive-ground systems, the manufacturer puts out a similar circuit with a *p-n-p* transistor, and reverses polarity of all diodes and the meter.

Some of the accessory tachometers, though, are designated "universal" types. They achieve this by keeping all circuitry above ground, feeding input through a capacitor. Then the appropriate power terminal of the tach can be grounded and the other connected to the hot side of the ignition switch.

A few of the accessory designs appear to have crowded scales near the top of their ranges; this is usually due to the use of moving-vane meters rather than the d'Arsonval type, in the interests of economy. Manufacturers who use only d'Arsonval movements claim higher accuracy (2% as opposed to 5%) and easier reading of the indicator at high rpm.

Calibration

Commercially built tachometers usually provide no calibration control available to the user. However, calibration can be easily checked with an audio-frequency square-wave generator, and can be corrected if necessary by adjusting values of meter shunts.

To calibrate an electronic tachometer, keep in mind that it receives one input pulse every time the breaker points open and a sparkplug fires. In a four-cycle engine, any given plug fires once for every two revolutions of the crankshaft. In a 6-cylinder engine, this means the distributor points will open 6 times in 2 revolutions, or 3 times per revolution. Since electronic measurements are usually made in cycles per *second* while engine speeds are measured in revolutions per *minute* we must convert the ⅓ revolution-per-pulse figure by multiplying by 60 seconds per minute. This gives us ⅓ times 60 or 20 as the ratio of rpm to pulses-per-second. Thus an input frequency of 60 pulses per second, for calibration, should give a reading of 1200 rpm.

The exact formula relating frequency and rpm for all four-cycle engines is: 120 times calibration frequency/number of cylinders. Thus with an 8-cylinder engine the ratio would be 120 times 60 divided by 8, or 900 rpm for a frequency of 60 cps.

Ordinary line voltage, passed through a double-diode clipper to approximate a square wave provides an excellent calibration source of accurate frequency. For higher rpm readings, 440 cps is easy to obtain with a standard orchestra tuning fork or by checking against WWV.

If the tach reads higher rpm than the formula indicates, its shunt resistor should be reduced in value. If the reading is low, the resistor value should be increased. ▲

COMMUNICATIONS SYMPOSIUM

ONE of the most comprehensive programs on world-wide communications has been planned for the first International Symposium on Global Communications, which will be held on the campus of the University of Pennsylvania and at the Sheraton Hotel, Philadelphia, June 2 to 4.

Over 120 speakers from here and abroad will present 87 papers accenting the new close ties of communications and data processing. A keynote session will cover world-wide communications systems here and in the United Kingdom, Japan, and France. Military techniques will also be covered.

Sponsors include IEEE Professional Groups on Communications Systems and Computers and Univ. of Penna., where interested parties may register. ▲

Transistor Amplifier

(*Continued from page* 45)

transistor being checked, then we feel that such meters can be used for quick, non-quantitative checking.—Editor.)

It is also advisable to use a low-wattage soldering iron and a soldering aid when repairing transistorized equipment. Again, no internal leakage path should exist between the line and the soldering iron. As a further precaution, the iron should be grounded to the amplifier chassis.

When servicing this unit or any other transistor amplifier, we suggest that these simple rules be followed:

1. Be careful when working with transistors, since they may be destroyed almost instantly. This is in marked contrast to tubes which can usually bear moderate overloads for much longer periods.

2. Never work on a transistor amplifier without first disconnecting it from its source of power.

3. Guard against shorts—one of even brief duration between the collector and base of any transistor will destroy that transistor and often those associated with it (as in the case of Darlington-connected transistors or those in the output stage of the power amplifier). Such shorts may be produced even in the time it takes for a dropped screwdriver to glance off a pair of socket terminals, or to connect one of the terminals and the chassis.

4. Damage will occur to any transistor if its base is placed at or near the same potential as the collector. Therefore, check that the base leg of the biasing circuit is not open on the emitter side of the circuit.

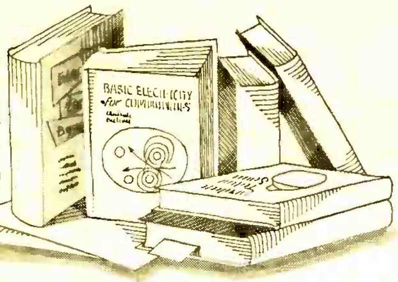
5. When replacing power transistors, be sure that heat sinks and mica insulators are free from metal shavings which might cause shorts or prevent sufficient heat transfer from the transistor to the heat sink.

6. Use silicone grease (such as *Dow-Corning* No. 3 or No. C20194) between heat sink and mica insulators, as well as between mica insulators and transistors, for better heat conduction.

7. Always use a pair of long-nose pliers or other heat sink when soldering transistors (or other low-wattage components). Grasp the lead to be soldered between the body of the transistor and the soldering iron. This will prevent heat from reaching the transistor junction and damaging the device.

Despite the relative newness of transistors in high-fidelity equipment, there are many reasons which recommend them to the consumer. The fact that major manufacturers are making such equipment part of their new lines indicates the confidence the industry places in transistor components. ▲

BOOK REVIEWS



"TRANSISTOR CIRCUITS FOR MAGNETIC RECORDING" by N. M. Haynes. Published by *Howard W. Sams & Co., Inc.* 379 pages. Price $9.95.

The application of transistor circuits to magnetic recording equipment has generated a need for a clear-cut and easily understood exposition of this field. The author, who is engineering vice-president of *Amplifier Corp. of America*, has tackled the job in a straightforward manner.

The text is divided into four main sections plus appendices. The first section deals with transistors—fundamentals, as a circuit element, and circuit stabilization. He next deals with magnetic recording elements—noise considerations, recording/playback fundamentals, electrical components, and circuit requirements. The third section takes up specific circuit components—preamplifiers, equalization, drivers and amplifiers, ultrasonic oscillators, output and indicating circuits, and motor-control circuits. The last division deals with system circuitry and covers recording and playback circuits, switching schemes, composite circuits, frequency-modulated recording, and digital recording.

Much of the material included in this volume is applicable to such divergent fields as: hi-fi amplification, instrumentation, telemetry, automatic control, and in the general area of transistorized communications equipment.

° ° °

"TRANSISTOR TELEVISION RECEIVERS" by T. D. Towers. Published by *John F. Rider Publisher, Inc.* 188 pages. Price $6.95.

This volume is subtitled "A Survey of World Circuitry—British, American, German, Russian, Japanese" which indicates the scope of this book. With the advent of the transistor in 1948, subtle changes have been occurring in TV receiver design with the 1960's registering an impressive acceleration in the use of transistors throughout the set.

The author covers the salient features of transistor TV receivers built in the five leading TV set-making countries and presents a complete analysis of each phase of transistor TV structure and specifies the different methods used in each country. The author compares the various makes of transistor receiver to each other and to conventional tube sets. Separate chapters cover transistor tuners, video i.f. amplifiers, the video amplifier, sound sections, the picture tube and its associated circuits, power supplies, and service techniques.

The text material is illustrated with partial schematics and line drawings.

° ° °

"WORLD RADIO-TV HANDBOOK" by Olaf Lund-Johansen. 266 pages. Price $3.50 postpaid. Available in the U.S. from *Gilfer Associates*, P.O. Box 239, Park Ridge, New Jersey. 18th Edition.

This 18th Edition of the Handbook has been expanded to include 20 more pages of information than the 1963 version. It carries a listing of broadcasting schedules, frequencies, powers, programming, station personnel, mailing addresses, etc. of every known short-wave broadcasting station—including those behind the Iron Curtain.

In addition to the schedule and station information, this edition carries articles by well-known personalities in the field of broadcasting. Details on TV, number of listeners, frequency bands, sun-spot cycles, interference and jamming, clubs, and world times are also included in this volume for the dedicated SWL.

° ° °

"TRANSISTOR IGNITION SYSTEMS HANDBOOK," by Brice Ward. Published by *Howard W. Sams & Co., Inc.* 126 pages. Price $2.50. Soft bound.

One "optional" automotive accessory which gained almost immediate consumer acceptance is the transistor ignition system. Since some cars are now equipped with units supplied by the auto maker or systems installed by the user, this book should find a ready made audience.

This volume covers all phases of transistor ignition systems from coil design and switching circuits to practical and commercial systems, installation, and troubleshooting. In three appendices the author provides a listing of most of the currently available commercial systems along with their characteristics, a list of parts used in ignition systems, and a directory of manufacturers of such ignition systems along with their addresses.

Tables, graphs, performance curves, photographs, and schematics are all used to amplify the text material.

° ° °

"MATHEMATICS FOR ELECTRONICS AND ELECTRICITY" by NRI Staff. Published by *John F. Rider Publisher, Inc.* 248 pages. Price $3.95. Soft bound.

This volume was prepared by the National Radio Institute Staff to meet the need for training in the specialized mathematical techniques required in electronics. The text covers every phase of useful mathematics as related to electronic circuitry and begins with a review of arithmetic. The book progresses through algebra, trigonometry, Boolean algebra, and the binary number system. In each instance the topic is related to its electronics application.

° ° °

"DIODES AND TRANSISTORS—GENERAL PRINCIPLES" by Guy Fontaine. Published by *Hayden Book Company, Inc.* 470 pages. Price $9.50.

This is a *vade mecum* of transistor basics for the engineer or advanced student. The author provides a comprehensive review of the principles underlying all semiconductor devices and then goes on to discuss the various types of transistors and semiconductor diodes—including an analysis of the performance characteristics of each.

A detailed presentation and analysis of all the parameters of transistors of interest to engineers takes up most of the balance of the book. Where applicable, there is a comparison with similar parameters of vacuum tubes. The final section details methods, including all necessary formulas and equations, of designing transistor circuits for various electronic applications.

Two- and three-color diagrams are used throughout to illustrate and emphasize the text material. The author has attempted to cover his subject with minimum reliance on the mathematical approach but, where necessary, this treatment is at the level of high-school algebra.

One mechanical detail may disturb some users and that is paragraphs are not indented. When using the text a soft pencil should be at hand to mark the new starting point after referring to the related diagrams and graphs accompanying the text.

° ° °

"NORTH AMERICAN RADIO-TV STATION GUIDE" by Vane A. Jones. Published by *Howard W. Sams & Co., Inc.* 128 pages. Price $1.95. Soft bound.

This is the 1964 edition of a popular reference manual containing up-to-date and complete information on broadcast stations operating on the North American continent. The listing covers 7500 stations by city, state, and frequency. Of this number 5000 are AM stations, 1500 FM stations, and 1000 v.h.f. and u.h.f. TV stations. ▲

MONO USE OF STEREO PHONES HAVING TWO PLUGS

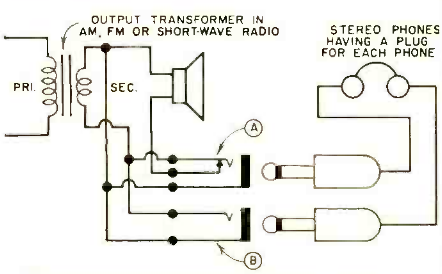
By ART TRAUFFER

SOME stereo and binaural headphones come equipped with two phone plugs (one for each phone). Because of their quality, they offer possibility for mono listening to AM and s.w. sets. Here are two simple ways to use these twin-plug phones monophonically without any changes in the plugs.

In Fig. 1, if you already have a circuit-closing phone jack wired into the v.c. circuit, all you need do is add an open-circuit jack as shown. This will connect the phones in parallel for mono.

In Fig. 2 an adapter can be built instead of the extra jack of Fig. 1. All you need is an *Amphenol* Type 75-MC1P phone plug, two open-circuit phone jacks, and a small tin box to mount them. Note that the three parts are soldered securely to the tin to insure dependable connections. The jack at the left is mounted upside down so the two lugs can be soldered together at one end of the wire lead. The tin can automatically connects the frames, or "grounds," of the three parts. To use this adapter, simply plug it into the jack in the v.c. circuit of your radio, then plug the twin plugs of your stereo phones into the adapter.

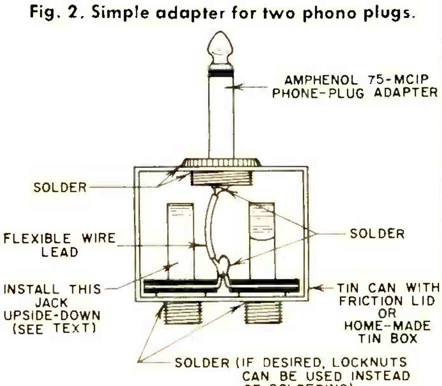
If one side of the speaker voice-coil in your a.c.-d.c. radio is connected to the chassis, isolate the v.c. and transformer secondary to avoid shock. ▲



Ⓐ CIRCUIT-CLOSING JACK INSTALLED IN RADIO FOR MONO LISTENING
Ⓑ EXTRA JACK INSTALLED FOR PHONES HAVING TWO PLUGS

Fig. 1. Extra jack is connected in parallel with circuit-closing jack for mono.

Fig. 2. Simple adapter for two phono plugs.



Transistor Ignition System

(*Continued from page* 51)

be shorted out of the circuit entirely.

A problem introduced by the use of the relay is that it will be impossible to switch off the engine if "idiot lights" are used to indicate battery charge because there will be a return path through the light bulb of the charge-indicator circuit. The ignition switch is bypassed and the coil of the relay will be energized at all times.

The bulb lead is generally connected to the voltage regulator. It should be disconnected and a 0.5-amp., 400 p.i.v. silicon rectifier diode inserted in series between the bulb lead and the voltage regulator. The cathode of the diode goes to the regulator terminal. This rectifier is not required on alternator-equipped cars.

There are several 400:1 turns-ratio coils available now and one of them is specified in the parts list. Ballast resistors can also be purchased from the same supplier.

Although a definite value is specified for ballast resistor *R*1, optimum results are obtained with the primary of the ignition circuit drawing 10 amps, with the engine stalled and the ignition key turned on. With the engine operating, this current should be between 5 and 8 amps at idle.

Adjust the value of ballast resistor *R*1 to obtain the specified current. A stalled-engine current of between 9 and 10 amps will be satisfactory.

Reliability of this circuit was demonstrated by the more than 100,000 miles of operation in several cars under continuing observation without any failures to date.

Careful workmanship and proper choice of location for the transistors and diodes is of prime importance. Do not mount the semiconductors on the engine or near the exhaust manifold. The best location would be inside the passenger compartment, under the dashboard.

Readers are referred to their August and December 1962 issues of ELECTRONICS WORLD for the 6-volt negative- and positive-ground and 12-volt positive-ground circuits, for detailed explanation of the circuit and for construction details. The two circuits are basically the same and this one can be modified without any trouble and used with positive-ground and 6-volt systems.

It must also be emphasized that, as with any ignition system—standard or transistorized, the ignition switch should be turned off at the end of a drive to keep transistors, diodes, and ignition coils from overheating.

The heat sinks should be insulated from the auto chassis.

Feedthrough capacitors of 30-40 amps should be used at the ignition coil, voltage regulator, and generator to keep radio interference to a minimum, if this becomes bothersome. It is also a good idea to keep the standard ignition in the car for emergency use and to simply add the transistorized ignition.

Point setting and sparkplug gap should be that specified by the car manufacturer. Installation of new points is recommended once the circuit is tested and works properly. Correct point gap and dwell, as well as correct timing, are very important and should be set by means of proper instruments.

With the changes and additions specified, this circuit should operate for the life of the car without any trouble, except perhaps for the replacement of points at 50,000-mile intervals due to wear of the rubbing block. Application of a thin film of high-temperature grease to the distributor cam at 5000-mile intervals would lengthen rubbing-block life. Point dwell should also be checked at this time and corrected if necessary. Any dwell angle change will be due to rubbing-block wear. ▲

DEW Line "Radicians"

(*Continued from page* 49)

by married men. Surprisingly, most single men drop out after one or two terms, while some of the married men have been on the Line since its inception.

When one considers the importance of the DEW Line, it is not difficult to understand why extensive precautions are taken in selecting the right men.

After passing all tests and prior to being sent to the DEW Line, each prospective technician must attend a training course at the *FEC* Training Base in Streator, Illinois. Identical equipment is used and all prospective employees must learn maintenance, servicing, theory, and operation of the various types of equipment.

All technicians must sign a contract for eighteen months and additional terms are based on twelve-month contracts. Salaries vary—from $10,000 to $21,000 annually, depending on the length of service and responsibilities. All transportation from the point of recruitment, food, and housing are supplied free.

Working conditions are beyond expectations. Each base is well heated and such facilities as automatic washers and dryers are supplied. Each technician has a room of his own. Technicians must work nine hours a day, six days a week, which leaves sufficient time for hobby activities. In addition to each base showing three movies a week, technicians find time to indulge in such hobbies as photography, painting, hi-fi listening, and ham radio. ▲

Understanding Crystals

(*Continued from page* 38)

bility, by using normal or polarized light. In addition, the optic or Z axis is determined by visual inspection or by the use of optical methods. The crystal is then marked for cutting into crystal blanks.

Processing of the crystal blank usually begins with a lapping operation, as shown in Fig. 4 in which a number of blanks are lapped at the same time. Crystals are lapped and polished to a frequency slightly higher than the desired frequency. Crystals designed for overtone operation may be polished to a finer finish than that required for fundamental operation.

After lapping and polishing, the blanks are chemically etched as shown in Fig. 5. The etching process helps to prevent the crystal from aging and drifting in frequency after the crystal is processed.

In many communications applications, electrodes are plated directly on the crystal blank. Plating may be done by chemical deposition, evaporation under vacuum, sputtering or furnace-firing using silver or gold paints. The plating serves to bring the crystal to final frequency, and the frequency can be controlled to very fine limits by the thickness of the plating.

After plating, the crystal is mounted on a base. Although a variety of mounting techniques are employed in crystal manufacture, communications types are usually edge-clamped as shown in Fig. 6, using wire spring loops which serve both to hold the crystal and make electrical contact. The blank, mounted on its base, is then calibrated to its final frequency after which the covering can and base are soldered together. In some cases, the entire unit is evacuated and either sealed off under vacuum, or filled with dry nitrogen which serves to prevent aging due to the presence of moisture.

Crystals are then subjected to a number of checks which may include testing under a variety of temperature conditions and in oscillators which are exact electrical duplicates of those in which the crystal is to be used. Final frequency determination is done with an electronic counter to be sure the crystal will operate within the specified tolerance.

The crystal manufacturer will usually have on hand a vast amount of correlation data for all types of commercial communications equipment. For reasons given elsewhere in this article, it is important that the crystal manufacturer has specific and detailed information on the circuit in which the crystal is to be used. Otherwise, frequency tolerances cannot be met. Where crystals are required for home-made equipment such as frequency standards, recommended circuits of the crystal manufacturer should be closely followed.

Care of Crystals

While the modern communications crystal is a rugged device, care should be used in handling and operating it to assure consistent and uniform performance. The typical *AT*-cut overtone crystal is only a few thousandths of an inch thick and is subject to damage. You might drop a crystal 15 times without hurting it, but conversely, it might break on the first drop. If you hear things rattling around inside the can after the crystal has been dropped, it should be relegated to the wastebasket.

Circuit alterations which result in excessive drive current through the crystal, may also cause the crystal to fracture. Although this is a rare occurrence, excessive drive can also cause erratic operation.

Occasionally, you may find a faulty crystal which has a tendency to operate in more than one mode. It may oscillate at two different frequencies simultaneously. In the case of overtone crystals, these two frequencies may be reasonably close together. Other faults include the tendency to change frequency during operation—such crystals should be replaced. Crystals, like any other commodity, come in different qualities. Because of the vital function of the crystal in both communications transmitters and receivers, the safest practice is to buy the best crystal you can afford. Either buy directly from the equipment manufacturer or from a reliable crystal manufacturer, in either case giving all the pertinent data that is required. In so doing, you will avoid the problems encountered with poorly made crystals and you can be sure that your equipment will operate at peak efficiency for long periods of time. ▲

CITIZENS BAND JAMBOREE

THE Fresno Citizens Band Radio Club has scheduled its Second Annual Jamboree for June 6th and 7th. The affair will be held at the Wildwood Beach Country Club, on Highway 41 at the San Joaquin River, Fresno, California.

The committee has planned an interesting and varied program of entertainment including swimming, tennis, golf, fishing, games for the children, and a dinner dance on Saturday night.

Tours will be conducted for those who are interested and free parking will be provided for trailers and campers. Dealer demonstrations of the newest in CB equipment will be continuous.

Additional details on the affair plus reservations for the Jamboree can be obtained by writing The Fresno Citizens Band Radio Club, Jamboree, 231 Dennet, Fresno, California 93728. ▲

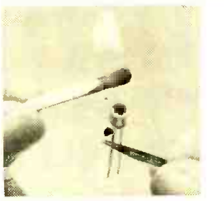
NEW PRODUCTS

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 15.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

SILICON PHOTOTRANSISTOR

1 **General Sensors, Inc.** is now in production on a new silicon "n-p-n" phototransistor, the GS-600. Because of its high sensitivity, this two-terminal device is especially suited for character recognition, card reading, and other pulse generation applications.



The phototransistor features a large base area providing optimum sensitivity from extremely low-level to high-level light detection. To provide superior optical characteristics, a glass window, rather than a lens, is hermetically sealed into the standard TO-18 header.

ALL-CHANNEL TV ANTENNA

2 **Channel Master Corp.** is now offering the "VU-82," an all-channel antenna which is designed to provide reception of v.h.f., u.h.f., color-TV, and FM-stereo.

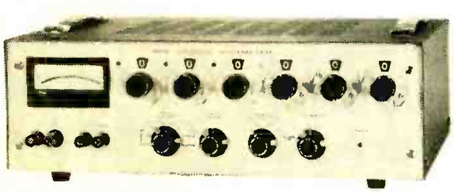
On u.h.f. the built-in diplexer circuit provides a uni-directional pattern that can be reversed 180 degrees by switching. On v.h.f. and FM, an impedance compensating switch eliminates dipole handling when changing channels within bands since it electronically adjusts the dipole to the wavelength of the channel. Impedance is 300 ohms.

This indoor antenna is housed in a compact enclosure with the elements attached to the case containing the switching elements.

DIFFERENTIAL VOLTMETER

3 **Keithley Instruments, Inc.** has developed a new differential voltmeter that features a low 0.01% limit of error with 0.005% stability indefinitely and measures d.c. voltages between 100 mv. and 500 volts.

The Model 662, a self-contained guarded potentiometer, operates from a 117- or 234-volt, 50/60-cps power source. It has infinite input im-



pedance at null over its entire range and offers maximum null sensitivity of 100 μv. full-scale with 3-μv. resolution. Six-dial readout gives at least five-dial resolution for every voltage setting. Repeatability is $\pm$0.0025%.

The instrument measures 17½" wide x 13" deep x 5½" high and is offered as a bench model. It can be rack mounted by means of a special accessory kit.

FREQUENCY CONVERTER

4 **Dymec**, a division of **Hewlett-Packard Co.** has announced the availability of a new frequency converter which permits precise frequency measurements in the range 1 to 12.4 gc. The Model 5290A is designed for full compatibility with the company's electronic counters to extend their measuring capability to the microwave range.

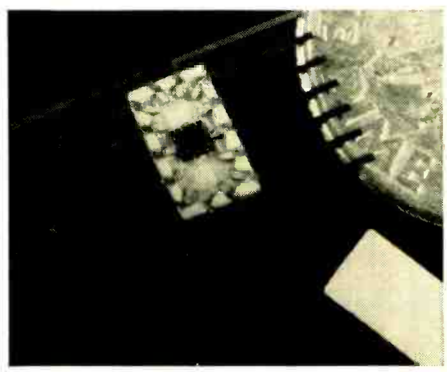
The unit provides positive phase locking of an internal transfer oscillator to the signal frequency, resulting in frequency measurements with accuracy equal to that of the counter time base. Positive locking allows measurement of drift and jitter over long time periods. Additional features permit frequency measurements of pulsed signals, FM measurements at deviation rates to 1 mc., and measurements of AM and FM on rapidly drifting signals.

The circuitry is all solid-state and all r.f. circuits are totally enclosed in a solid casting to virtually eliminate RFI.

INTEGRATED CIRCUITS

5 **Motorola Semiconductor Products Inc.** is using three flat package configurations of high-impact, high-thermal conductivity ceramic for its standard integrated circuits.

The company lists the advantages of these new packages over glass flat packages as: 1. The high-



temperature ceramic material is matched for thermal expansion with kovar, a lead material proven in use with standard hermetically sealed transistor packages. 2. Thermal conductivity 3 to 4 times greater than that of glass to provide better heat dissipation. 3. The new hermetic sealing approach not only achieves higher yields but results in package reliability previously unobtainable in flat packages. 4. Dog-leg lead structure, difficult to achieve with glass packages, is available in the ceramic flat package.

Various integrated circuits and lead configurations are available.

COMPACT INVERTER

6 **Terado Corporation** is now marketing a new inverter which operates from a standard car battery and is designed especially for powering small portable TV sets and similar electrical equipment.

Known as the "Satellite" Model 50-138-3, the unit is lightweight, easy to install, and provides a 110-volt, 60-cycle output. Connection can be made either to the cigarette lighter in the car or direct to the car battery.

IN-CIRCUIT TESTER

7 **Test Equipment Corporation** has a new in-circuit transistor tester on the market as the Model 5. The instrument measures true pulsed beta of transistors installed in circuits. Simplicity of operation has been achieved through automatic control circuits which adjust the test conditions to provide a direct reading of beta from 5 to 500 on a single meter scale. The pulsed current is 5 ma. with a duty cycle of 25%.

Protective circuits have been incorporated to prevent damage to the transistor under test. The instrument has been designed for production

line, laboratory, and maintenance operations. An adjustable accessory fixture holds printed-circuit cards under a template to permit rapid and accurate testing by non-technical operators.

The unit measures 5¼"x 12"x 11" and weighs 10 pounds. It operates on 117 volts a.c.

TV-FM DISTRIBUTION AMPS

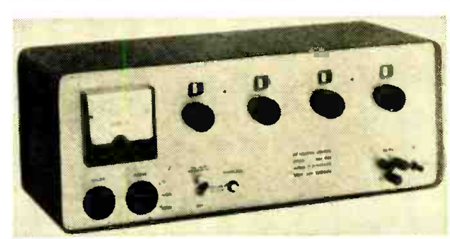
8 **Winegard Company** is currently marketing three easy-to-install TV-FM distribution amplifiers. Each has flat frequency response, no phase distortion, and full gain to the top of the FM band. They use all high-transconductance low-noise triodes exclusively. An extended band-pass allows cascading without clipping the ends of channels 2, 7, and 13. There is low-noise neutrodyne input circuitry and the noise figure remains optimum no matter where the gain controls are set, according to the company.

All jacks, controls, switches, and connections are accessible from the top of the chassis. There is a special preamp switch which provides 30 volts a.c. at the input jack to operate the company's antenna preamps. This feature eliminates the need and cost of a separate preamp power supply.

A.C. VOLTAGE CALIBRATION

9 **Horex Electronics, Inc.** is now offering a new high-accuracy a.c. voltage source to permit the fast calibration and checkout of all r.m.s. indicating voltmeters of the digital, moving vane, and d'Arsonval/rectifier type.

With the instrument, the usual method of first generating a voltage and then measuring it with a calibrated meter or even transferring it to a known d.c. voltage has been reduced to a simple dialing of the desired r.m.s. voltage. The company estimates that the usual 6-range voltmeter



can be checked out in seconds at an accuracy of 0.1% of reading or better.

The unit measures 19"x 7"x 8" and is available in bench or rack versions.

CAPACITANCE BRIDGE

10 **Electro Scientific Industries** has released its Model 976 "Portametric" portable capacitance bridge which features an accuracy of $\pm$0.1% plus one dial division and measuring capability from 0 to 1.2 μf. in four ranges and 1 pf. resolution in the lower range.

Use of a transformer circuit permits two- or three-terminal grounded or ungrounded measurements, making the unit ideal for production line or field service use. The bridge is specially designed for optimum loading measurements, mutual capacitance matching, and quality control measurement as required by REA. Dissipation factor readout and provision for audible nulling is included.

A solid-state low-drain tuned generator and 1-kc. generator provide a 1000 hour battery life from a six "C"-cell power supply.

BULK AVALANCHE SCR'S

11 **International Rectifier Corp.** has added 32 expitaxial 70-ampere bulk avalanche silicon controlled rectifiers to its line. These new units exhibit true bulk avalanche characteristics in both forward and reverse directions and carry voltage ratings ranging from 600 to 1300 volts. Minimum reverse avalanche breakdown voltage (at −40 degrees C) ranges from 700 to 1400 volts.

These new SCR's have been assigned two series of JEDEC numbers covering 2N3091 through 2N3106. Each series is composed of 8 rectifiers graduated in increments of 100 volts. The 2N3099 through 2N3106 offers a specific maximum reverse avalanche breakdown voltage of 900 through 1600 volts.

SERVICE VOLTOHMMETER

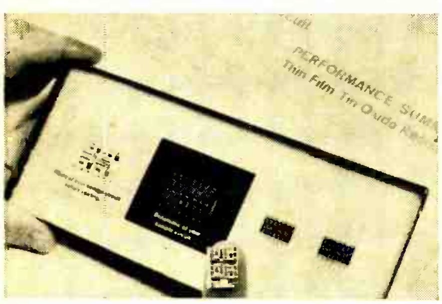
12 **Lafayette Radio Electronics Corporation** has announced a new service v.o.m. rated at 20,000 ohms/volt and with a 6" meter face.

The Model TE-900 has six a.c. voltage ranges from 0 to 5000 volts; d.c. current from 1 to 10 amps in six ranges; and three ohmmeter ranges from 0 to 20 megohms. Decibel readings are covered from −20 to +50 db. The d.c. accuracy is ±3% full scale, a.c. is ±4% full scale, and resistance ±3% full scale.

The instrument is housed in a heavy gauge steel case which measures 6¼"x 7¾"x 3⅛".

EVALUATION MICROCIRCUITS

13 **Corning Glass Works** is marketing two evaluation microcircuits, each containing a dozen thin-film tin oxide resistors, in kit form. Each



12-resistor microcircuit is on a wafer 7⁄16"x 11⁄16". Substrate material is alumina, glazed with a special aluminosilicate glass. The resistors have values of .5, 5, and 50,000 ohms.

Beside the two microcircuits, the kits include a schematic diagram of the test circuit, a photo of the circuit before coating and lead attachment, and technical information listing typical microcircuit performance and specifications.

CABLING TOOL

14 **Panduit Corporation** is now offering a new "gun type" manual cabling tool, the GS-2B. The new tool is of the direct (in-line) feed type with strap cut off at a preset and controlled strap tension. The tension level is readily controlled and adjusted without the need for separate and auxiliary tools.

The tension setting can be easily calibrated for complete operator convenience and control. The same tool is used to install both the standard and miniature line of cable ties, clamps, and identification markers offered by the firm.

DETENTED U.H.F. TV TUNER

15 **Oak Manufacturing Co.** has announced a detented u.h.f. television tuner which provides 15-degree automatic "lock-in" selection of each of the 70 u.h.f. channels.

The tuner measures 2½"x 1¾"x 1⅛" and is designed for the OEM market. The basic tuner uses 270 degrees to tune all 70 channels and utilizes about four degrees per channel. The tuner is designed for continuous two-way rotating action, in either direction, from channel 14 to 83 in a manner similar to that of the conventional v.h.f. tuner which operates between channels 2 and 13.

HEAT-SHRINKABLE RUBBER

16 **Dow Corning** has developed a new heat-shrinkable, heat-stable, high-strength silicone rubber which can be shrink-fitted to the contours of connectors, cables, and wire bundles.

Marketed originally in the form of tubing and molded parts, the new material shrinks to one-half its as-supplied diameter when heated briefly at temperatures above 300 degrees F. Standard tubing sizes in nine diameters from ⅛" to 1½", measured after shrinking, are available from stock. Other sizes and custom-molded shapes are available on special order.

U.H.F. TV ANTENNA

17 **Blonder-Tongue Laboratories, Inc.** has recently introduced a new u.h.f. television antenna which is based on the periodic principle. Called the "Golden Dart," the new antenna features the use of unbreakable polypropylene insulators to maintain the proper distance between the lead-in wire and the antenna. This minimizes standing-wave ghosts resulting from faulty impedance match, according to the manufacturer.

The unit is preassembled and has all-welded joints. It is completely weatherproof and thumb-tightened stripless screws for twin-lead connection and the D-bolt mast mounting make installation easy.

HI-FI — AUDIO PRODUCTS

MINIATURE PICKUP

18 **Pickering and Company, Inc.** has recently developed the V-15 "Micro-Magnetic" stereo cartridge, a miniature 5-gram unit for use with low-mass tonearm systems.

Because of its high compliance, high output, and rugged construction, the company is offering it for use in either manual turntables or record changers. Response is flat from 20 to 20,000 cps with output 7.5 mv. per channel at standard recording levels. Vertical tracking angle is 15 degrees.

The V-15 features the company's replaceable stylus assembly.

MATCHED CARDIOID MIKES

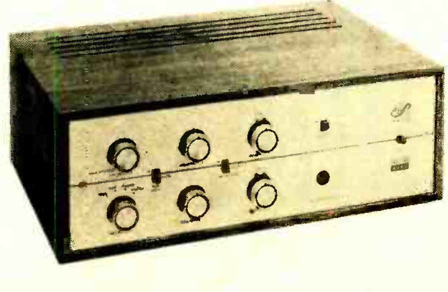
19 **Turner Microphone Co.** is now marketing the "Stereo Twins"—two perfectly matched cardioid dynamic microphones specifically designed for sale to owners of high-quality tape recorders.

The microphones come complete with plugs to match most stereo recorder inputs.

50-WATT STEREO AMPLIFIER

20 **Eico Electronic Instrument Co. Inc.** is now offering a 50-watt (IHF) stereo amplifier as the Model 2050 in its "Classic Series."

IM distortion each channel is 2% at 22 watts, 1% at 17 watts, 0.2% at 5 watts, and 0.1% at 2 watts. Harmonic distortion is 0.5% at 17 watts, 40-20,000 cps; and .3% at 5 watts, 30-20,000 cps. Frequency response is 10-40,000 cps ±1 db. Speaker outputs are 8 and 16 ohms with four inputs (magnetic phono or adapted ceramic phono, tuner, tape, auxiliary). Sensitivity is 1.7 mv. on phono and 180 mv. on other inputs. The circuit requires 11 tubes.



The amplifier measures 5⅜"x 15⅞"x 11⅝" and weighs 25 pounds. It is being offered in both kit and wired versions.

TRANSISTOR TAPE RECORDER

21 **North American Philips Co., Inc.** is now on the market with its new "Norelco Continental 101," a self-contained, portable, battery-operated transistor tape recorder which is designed to be used with a broad range of optional accessories.

The recorder operates by means of two push-buttons for record and one for playback. It weighs only 7 pounds for easy portability and

uses standard "D" flashlight cells. The special transistor circuitry draws less current, making possible as much as 40 hours of recording with one set of batteries.

Frequency response is 80-8000 cps. A treble-bass tone control permits the user to dial the exact tone desired. The recorder comes with an ultra-sensitive dynamic mike. The instrument can also record from a radio, phonograph, or TV set by means of a special input jack. A second input jack is designed to accommodate some of the accessories—headphones, remote mike switch, a.c. adapter, among others.

The unit operates at 1⅞ ips and will provide up to two hours playing time on a single 4-inch reel. It has an erase head and a narrow-gap two-track record/playback head.

DIVERGENT-LENS SPEAKER SYSTEM

22 **Empire Scientific Corp.** has developed a divergent-lens speaker system which provides a sound radius of 360 degree dispersion which eliminates the need for painstaking location and balancing of speakers.

The "Grenadier" features an exclusive symmetrical sonic column design which is acoustically engineered to fit any room layout. It can be used in corners or against walls and is totally rigid without resonance.

The three-driver magnetic structure is capable of handling up to 100 watts of music power without overload or burnout.

The Model 8000 has a frequency response of 30-20,000 cps and a nominal impedance of 8 ohms. The system is housed in a mar- and stain-proof enclosure which measures 15¼" in diameter, 29" high, and weighs 65 pounds.

ANTENNA FOR FM STEREO

23 **Channel Master Corp.** has put the "FM Rondo" antenna on the market to meet the need for a unit capable of providing good sensitivity and omnidirectional performance across the entire FM band.

The antenna features three individual dipoles in parallel which provide a roughly circular reception pattern on all FM-stereo frequencies. According to the company, the single-bay antenna is up to 2.5 db better than a single-bay turnstile on its strongest sides and up to 7.4 db better than a turnstile on its weak sides. The gain of a stacked "Rondo" is up to 7.3 db better than a stacked turnstile in the same service.

STEREO TAPE RECORDER

24 **Concertone** has entered the medium-price field with its Model 801 stereo tape recorder.

The new unit incorporates the firm's "Reverse-O-Matic" feature which is now engineered to record in both directions as well as playback. A three-motor tape transport system provides automatic two-direction record and play through the use of six heads, three for each direction, and utilizes a symmetric center capstan drive.

The Model 801 also features solid-state record and playback preamplifiers and, in addition, has all-push-button operation with optional remote control. It is housed in a portable carrying case with built-in stereo speaker/amplifier and includes two microphones and reels.

OMNIDIRECTIONAL SPEAKER

25 **Interacoustics Corporation** has recently introduced its "Model One," an omnidirectional loudspeaker system which utilizes a unique design principle. Taking advantage of the directional qualities of a speaker by projecting sound upwards against a 90-degree conical acoustic reflector, the sound is reflected and directed into a 360-degree spherical polar pattern. The acoustic properties of the walls and ceiling of the room are brought into the system as secondary radiators.

According to the company, for stereo operation, the "Model One" eliminates the need for critical speaker placement as there can be no "dead stereo" locations.

The unit is a four-speaker system, with two woofers operating below 500 cps, a mid-range unit, and a tweeter. Impedance is 8 ohms and the speaker is designed to be used with amplifiers rated at 20 watts or better. The system is housed in a solid wood cabinet measuring 15" wide x 13" deep x 22" high.

MOBILE AMP/SIREN

26 **Bogen Communications Division** has developed a deluxe 35-watt mobile transistorized public-address amplifier which can be used as an electronic siren or fog horn as well.

The Model BT35 is designed for police, Civil Defense, fire, marine, and p.a. applications. It operates on 12-15 volts d.c. and can accommodate a low-impedance microphone, a high-level tuner. (or phonograph or tape recorder), and another high-level input. Two-way radio may be amplified so it will be clearly audible outside the vehicle.

When used with the SF-1 siren/fog horn generator, the BT35 can be used as a 55-watt electronic siren or fog horn. The SF-1 can be attached to the amplifier and may be operated automatically or manually.

BOOKSHELF SPEAKER SYSTEM

27 **Lafayette Radio Electronics Corporation** has added the "Decor-ette III" to its line of speaker systems.

Designated SK-275, this three-way system uses three British-made speakers to provide an overall response of 30 to 30,000 cps. The speakers include a 12-inch woofer with special foam-treated cone and free-air resonance of 35 cps, a 6-inch mid-range unit with closed back to prevent interaction with the woofer, and a sealed cone-type "super" tweeter. The enclosure is of the sealed type and has a tuned tube-type duct. Crossover points are 2000 and 5000 cps. Maximum power rating is 25 watts continuous or 50 watts intermittent peak, but the system may be used with amplifiers rated as low as 10 watts. Impedance is a nominal 8 ohms.

The system measures 14"x 24"x 12" in its oiled walnut cabinet. It is finished on all four sides.

CONTINUOUS-LOOP PROJECTOR

28 **The Kalart Company, Inc.** has developed a "Soundstrip" projector for use in audio-visual programs where still pictures with sound or talking still pictures can be presented automatically and continuously.

The system involves 35-mm. filmstrips on which color transparencies and an optical sound track are photographically printed side-by-side. Filmstrips of any length from 5 pictures with 2 minutes of sound up to 100 pictures with 30 minutes of sound can be projected automatically or, on electrical signal, from a continuous loop. Because pictures and sound track are on the same film, they cannot get out of synchronization or sequence.

COLOR-CODED RECORDING TAPES

29 **Ampex Corporation** has designed a new series of color-coded, heavy-duty audio recording tape for long-wear use in education, industry, government, and research applications.

Designated the "Color-Coded Series," the new tape has a 1.5-mil Mylar base with a heavy-duty oxide formulation which prevents the oxide from flaking or rubbing off and insures clean recorder operation.

A pressure-sensitive box binding, on which subject description may be written, is included with each reel of tape.

SLIDE-SYNC RECORDER

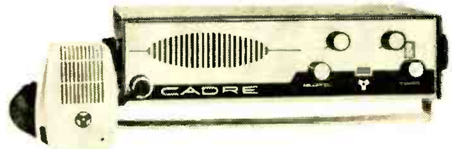
30 **Superscope Inc.** is currently introducing the new Sony Model 211-TS "Tapecorder" which features an inaudible electronic synchronization of slides. Designed to meet the needs of photographers, students, and educators, the new unit has an exclusive built-in sync/pulse generator for automatic, inaudible programming of slide shows synchronized with tape recorded narration, music, or sound effects. The 211-TS also features special student/teacher comparison facilities for language study purposes and for multiple recording.

CB-HAM-COMMUNICATIONS

TRANSISTORIZED CB UNIT

31 **Cadre Industries Corporation** has added the Model 510-A to its line of completely transistorized two-way radios.

This five-watt CB transceiver features redesigned audio, power supply, and variable tuner circuitry for improved performance and reliability.



All-channel tuning is locked directly to the five-channel crystal receiver; noise limiting and noise suppression are more effective; and current drain is further reduced. A new type of low-impedance ceramic microphone also eliminates background noise and increases desired audio response.

The Model 510-A comes complete with built-in a.c. and d.c. power supplies, push-to-talk microphone, accessory terminal board, mobile mounting kit, and channel-11 crystals.

COMPACT CB RADIOPHONE

32 **Pace Communications Corp.** has announced the availability of a new CB radiophone designed to meet the business and industry needs for short-range communications. Designed to provide dependable communications in ambient

temperatures from −20 to +200 degrees F. the Model 5000 features all-silicon transistor circuitry. New squelch control circuits are unaffected by random noise and can be set just once for operation in varying noise levels.

The unit can be rapidly changed from base station or mobile to a personal portable by means of plug-in power packs that adapt the unit to a battery carrying case for operation on 6, 12, 28, and 32 volts d.c. or 117 volts a.c. Snap-in modules allow easy replacement of transmitter, receiver, audio, control, and power-supply circuits.

C-BAND TRAVELING-WAVE TUBES

33 **General Electric Company** has available four new low-noise, C-band, single reversal (SR) traveling-wave tubes which offer a unique combination of light weight and low-noise characteristics not presently available in PM or PPM tubes. They provide size and weight advantages of about 50 percent over typical shielded PM-focused tubes of comparable performance. Low-noise advantages are from 2 to 5 db better than those available from a comparable PPM-focused

traveling-wave tube, according to the company.

Two broadband units covering the frequency range from 4 to 8 gc. are available and two narrow-band versions are also offered. All four tubes are of metal and ceramic construction and are supplied as completely packaged assemblies, including focusing structure, connectors, and housing.

23-CHANNEL CB TRANSCEIVER

34 **Electronics Communications, Inc.** is now in production on the "Courier 23," a new 23-channel CB transceiver with all channels crystal-controlled and all crystals supplied.

Using a technique of crystal synthesis, the new

unit achieves the same frequency stability with 12 crystals as the conventional unit using 46 crystals. In addition to this feature, the new unit also incorporates a built-in transistor power supply, built-in p.a. system, double conversion, 0.25 mv. sensitivity, headset/auxiliary speaker jack, single-knob tuning, illuminated channel indicator, an illuminated "S"-r.f. meter, 3-kc. bandspread control, and standby switch.

5-ELEMENT BEAM FOR CB

35 **Hy-Gain Antenna Products Corporation** is now marketing a 5-element beam which has been specifically designed for CB applications.

Known as the "Long John" Model 115-B, when vertically installed it develops 12.7-db forward gain over that of a tuned dipole. Front-to-back ratio measures 25 db while front-to-side ratio is 40 db. The antenna is equipped with the firm's "Beta Matching" system which results in s.w.r. at resonance measuring 1.05:1. Nominal impedance is 50 ohms.

The antenna is constructed of heavy gauge, taper-swaged aluminum tubing. Boom-to-mast bracket and element-to-boom brackets are of machine-formed heavy gauge aluminum. The insulators are constructed of molded high-impact plastic that is impervious to weather. Boom length is 24 feet and the longest element is 16 feet, 6 inches. It comes factory pre-tuned.

LINEAR AMP FOR SSB

36 **Sideband Engineers** is marketing a new linear amplifier that can boost the output of most single-sideband transceivers to a full kilowatt. The SB1-LA covers four bands: 80, 40, 20, and 15 meters. It was developed primarily for use with the company's SB-33 transceiver but can be used with any SSB unit.

The unit measures 11¾" square by 5½" high which makes it appropriate for mobile use. Without requiring any input tuning, the SB1-LA is a highly stable, passive-grid-input amplifier offering a 52-ohm resistive match to any SSB exciter. Output is conventional pi-net with all switching from the panel.

CB MARINE ANTENNA

37 **G.A.M. Electronics, Inc.** is now offering the Model CBM antenna which is designed specifically for use on boats equipped with Citizens Band radiotelephones. Its telescoping, 17-foot long, half-wave vertical radiator can be locked in a vertical position for use and in a horizontal position when not being used.

A matching transformer at the base of the antenna permits adjustment of v.s.w.r. to less than 1.1:1 on all 23 CB channels.

CB TRANSCEIVER

38 **GC Electronics Company** is now marketing the "Globe President VIII," a CB transceiver which may be operated on any of eight crystal-controlled channels plus a ninth channel which is available through an external crystal socket.

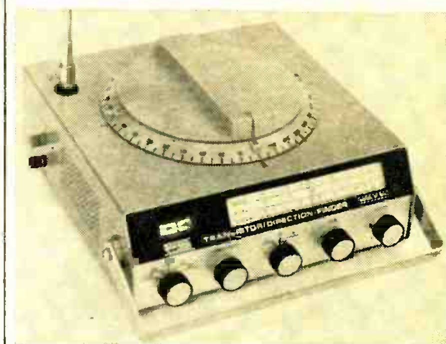
The transmitter features a full 5-watt input and 5 tube performance. The receiver is tunable over all 23 CB channels. The microphone is push-to-talk relay operated from transmit to receive positions.

An illuminated "S" meter instantly reads incoming signal plus relative output indications. Additional features include a built-in p.a. system, a triple-purpose power supply, adjustable squelch control, and 18 tube performance through twelve-tube/two-diode circuitry.

MARINE DIRECTION FINDER

39 **Pearce-Simpson, Inc.** is offering a fully transistorized, three-band radio direction finder, Model 364, which will operate on self-contained flashlight-type batteries.

The new unit will cover the beacon (including Consolan), marine, and broadcast bands. The



angled slide-rule tuning dial makes for easy readability. The null meter does double duty as a battery condition indicator.

The instrument is housed in a compact enclosure which measures 11½" deep x 10⅞" wide x 4⅞" high. A heavy chrome carrying handle makes the unit readily portable.

SEMICONDUCTOR SQUELCH

40 **Reach Electronics, Inc.** is now offering a compact, all-silicon-transistor squelch unit which prevents off-frequency signals from appearing in the output.

The "Hush-Gate" measures ¾" x ¾" x ¾" and can be installed by merely connecting four leads. No rewiring of the receiver is required. The encapsulated circuit will function without modification in virtually any communications receiver employing a discriminator and a squelch circuit.

PUSH-BUTTON ENCODER

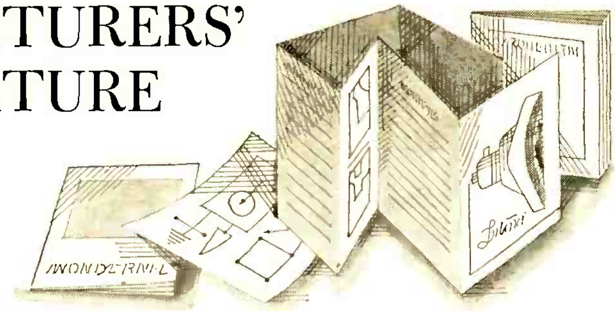
41 **G-E Communication Products Department** has developed a new push-button selective-calling console which permits up to 900 pocket radio voice-pagers, vehicular radios, or fixed base stations to be reached individually.

The "Encoder 900" is used with regular two-way radio dispatch equipment on an office desk or similar operating location. Compatible receivers may be called individually or collectively in sub-divided work groups or in total.

Specially designed tone governors assure frequency stability and elimination of interference between sub-systems. Audible coded tones are sent by radio to activate and alert desired receivers. Then a voice message is transmitted.

The unit is fully transistorized and power consumption is less than 10 watts. ▲

MANUFACTURERS' LITERATURE



MAGNETIC CONTROL OF SCR'S

47 **Firing Circuits, Inc.** has issued a 16-page technical booklet which discusses the theory of magnetic amplifiers designed to provide linear, proportional control of the output of silicon controlled rectifiers and thyratron tubes.

The treatise contains a technical introduction to magnetic power controls and a section explaining the theory of these units. Input signals from magnetic amplifiers are described, together with basic control curves to illustrate. Other sections include bias techniques, on-to-off ratios, output circuit considerations, snap-on (triggering), balance, response time, and a section on typical full-wave applications.

CAPACITOR CATALOGUE

48 **Texas Capacitor Company** has issued a 28-page catalogue covering an extensive line of Mylar and foil capacitors, metalized Mylar capacitors, and Teflon and foil capacitors. Each of these categories offers a number of capacitors with different electrical and physical characteristics. Details on each type are presented in tabular form for easy selection.

In addition to these standard items, the company also presents information on its facilities for designing and manufacturing capacitors for specific applications.

MICROMINIATURE POTS

49 **Miniature Electronic Components Corp.** is offering copies of a single-page data sheet which describes a new line of microminiature trimmer pots. These O-ring sealed, single-turn pots are available in several mounting and adjustment styles. The bulletin contains details on all new features, a list of applicable MIL specifications, as well as electrical, mechanical, and environmental specifications.

SILICON PLANAR TRANSISTORS

50 **Sperry Semiconductor Division** has issued a 32-page engineering handbook entitled "The Silicon Planar Transistor" in which the characteristics and applications of such devices are covered in considerable detail.

The transistors involved are listed in tabular form inside the front cover and then the text material deals with device characteristics and distributions, differential amplifiers, high-frequency characteristics—video amplifiers, noise characteristics, four-terminal regenerative switch, and low-level switching. Each section is lavishly illustrated with line drawings, graphs, bar diagrams, and schematics.

CONDENSED TUBE DATA

51 **General Electric Company** has issued a handy reference sheet which contains condensed data on 75 compactron types as well as prototype information. Since all major TV manufacturers are now using these tubes, this condensed specification sheet, plus the related basing diagrams, should prove helpful to manufacturers and others involved in TV set design and maintenance.

RECTIFIER STACKS

52 **Tung-Sol Electric Inc.** has issued an 16-page catalogue covering its line of high-current silicon rectifier stacks. Included are selection charts for single-phase center tap, single-phase bridge, three-phase bridge, and six-phase star stacks; dimensional diagrams of each type; current ratings vs ambient temperature graphs; and electrical characteristics curves for the various types of stacks.

OPTOELECTRONIC CONTROLS

53 **Raytheon Company** now has available a condensed data folder describing 19 models of "Raysistor" optoelectronic control devices. These four-terminal units perform a variety of control functions which are described in considerable detail in the publication.

Available models are listed in tabular form with control lamp voltage and current, signal photocell characteristics, general specifications, terminal connections, and mechanical specifications.

BASS-REFLEX ENCLOSURES

54 **Electro-Voice, Inc.**, believing that there are many audiophiles who prefer to build their own enclosures for their speaker systems, has published Technical Bulletin #10 entitled "Design and Construction of Bass-Reflex Enclosures" suitable for use with the firm's "Wolverine" and "Michigan" loudspeakers.

The publication includes basic considerations, such as enclosure types; proportions; volume,

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port, and duct dimensions; construction notes; and a large fold-out chart which permits the builder to select the appropriate dimensions for an enclosure to meet his specific requirements. Basic design data is tabulated in a separate chart for ready reference.

TERMINALS & CONNECTORS

55 **The Thomas & Betts Co.** has published a 56-page illustrated catalogue of terminals, splices, and installation tools.

The new catalogue contains illustrations of all of the firm's solderless connectors together with complete dimensional information. Installing tools, both hand and production types, are keyed to the types of fittings for which they are applicable. Military standards and specifications are referenced where pertinent.

STEEL STORAGE EQUIPMENT

56 **Penco Products Inc.** has issued a 48-page, two-color catalogue describing a complete line of industrial and commercial steel storage equipment. Catalogue 64 lists a broad range of steel shelving and related equipment, storage bins, storage cabinets, shop equipment including work benches and tables, clothing lockers, and book shelving. Specifications are listed for each type of equipment.

CB EQUIPMENT BROCHURE

57 **Raytheon Company** is offering copies of a new 8-page communications brochure which describes the firm's line of "Ray-Tel" CB two-way radios and accessories. Transceivers illustrated and described in the publication include the company's 10-channel TWR-3 in 12 or 117 volts and the 6-channel TWR-4, a 12- or 117-volt model with an "S" meter. Other communications accessories detailed in the brochure are mobile antenna systems, cable assemblies, crystals, and a series of noise-suppression kits for automotive use.

STATIC POWER CONVERSION

58 **General Electric Company** has published Bulletin GEA-7655, a six-page publication describing the firm's new line of static inverters and frequency changers.

The publication includes a discussion of the equipment, specification charts, pictures of typical models and applications, and design and features of the new line.

TELEMETRY FILTERS

59 **Kenyon Transformer Co.** has announced publication of an engineering monograph, "Optimizing Subminiature Subcarrier Telemetry Filters" by Walter Bein, director of engineering.

Four pages long, and illustrated with performance curves, tables, and block diagrams, the publication presents a straightforward "pre-design" specification technique intended to permit the telemetry engineer to get exactly what he wants electrically, mechanically, and economically, through use of a series of standard specifications derived from fundamental system requirements.

ELECTRONIC KIT CATALOGUE

60 **Heath Company** has issued a new special catalogue supplement which lists over 250 easy-to-build kits for the audiophile, radio amateur, professional technician, CB-er, boating enthusiast, as well as the home experimenter and the hobbyist.

Each item is pictured and described in considerable detail to allow the intelligent selection of an appropriate kit.

AUDIO ACCESSORIES

61 **Rye Sound** has issued two new catalogues listing an extensive line of audio equipment. Catalogue No. 1064 covers microphones for a wide range of applications from professional to industrial and special uses: headphones, microphone transformers, windscreens, stands, tripods, adapters; while the second publication lists an extensive line of earphones, headsets, private listening attachments, plus sound accessories of all types.

MILITARY CONNECTORS

62 **Amphenol** has available a new 96-page catalogue supplement which lists over 250 electrical connectors. The publication contains basic information about MS military connectors including nomenclature, construction available, shell types, inserts, and contacts. Special chapters cover "How to Select" and "How to Order" MS connectors.

SILICON LOGIC MODULES

63 **Digital Products** has issued Data Handbook DH-101 which describes the Series S silicon logic modules. The modules are plug-in solid-state digital modules for high-quality industrial, commercial, and ground-support applications.

The handbook describes the physical and electrical characteristics of the series as well as giving specifications for the individual modules. A loading chart is included to simplify design solutions by providing such parameters as input loading, output loading, and propagation and delay times for each logic module.

U.H.F. COMMUNICATIONS CAPACITORS

64 **Erie Technological Products, Inc.** describes a new line of u.h.f. communications capacitors designed for screen-grid, bypassing, and coupling of vacuum-tubes in an 8-page bulletin, No. 525.

The new capacitors have been designed for high-frequency operation and offer high volumetric efficiency—high capacitance vs chassis area occupied. This miniaturization offers a volumetric improvement 50% to 300% over other designs. Available capacitances are up to 10,000 pf.

POTENTIOMETER DATA

65 **Fairchild Controls** is offering copies of four data sheets covering its new "Faircon" line of potentiometers. A unique selection chart is featured to permit industrial engineers to pick the correct linearity and resistance for a specific job.

Available sheets include data on single-turn pots in 7/8", 1 1/8", 1 3/4", and 2" diameters.

LOUDSPEAKER CATALOGUE

66 **Jensen Manufacturing Company** is now offering a two-color, 16-page catalogue, No. 1090, fully illustrating and describing the many items in its "Concert," "Viking," and "Weather Master" series of general-purpose and replacement speakers.

Complete information regarding price, size of magnet, voice-coil size, impedance, and dimensions is included in the description of each speaker. In addition, the catalogue provides a discussion on permanent magnets and current advances in magnetic materials.

RESISTOR RELIABILITY

67 **Ultronix, Inc.** has available a four-page brochure which discusses reliability concepts and procedures in the manufacture of precision wirewound resistors.

The publication includes failure rate data and high reliability specifications met by the company's resistors and resistive networks. ▲

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33¢ TUBES. Radio & TV! Free list. Cornell. 4215-W University. San Diego, Calif. 92105

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GERMAN Electronic Publications. Free information. German Book Center, 1401 E. Hyde Park, Chicago 15, Ill.

SCATTERING beyond horizon. Amazing facts revealed. Booklet $1.00. J. Ronnevig, Box 6, Brooklyn 28, N.Y.

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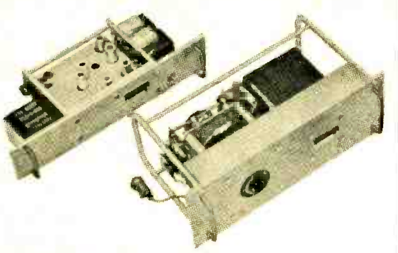

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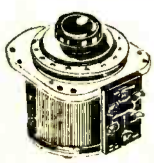

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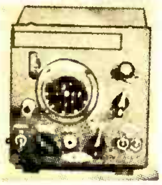

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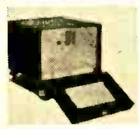

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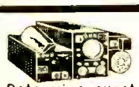

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We carry a complete line of replacement parts and accessories for above.

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Circuit diagram and connecting plugs available.

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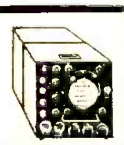

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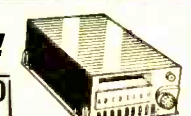

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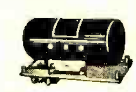

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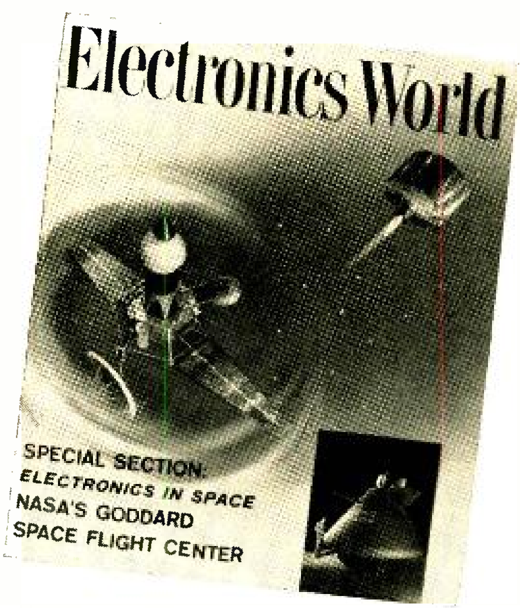

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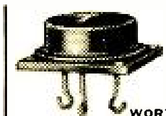

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- ☐ 2 CBS 35W PWR TRANSTRS, 2N1434, pnp, stud $1
- ☐ 10 FAMOUS CK722 TRANSISTORS, pnp $1

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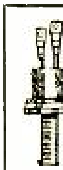

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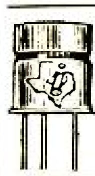

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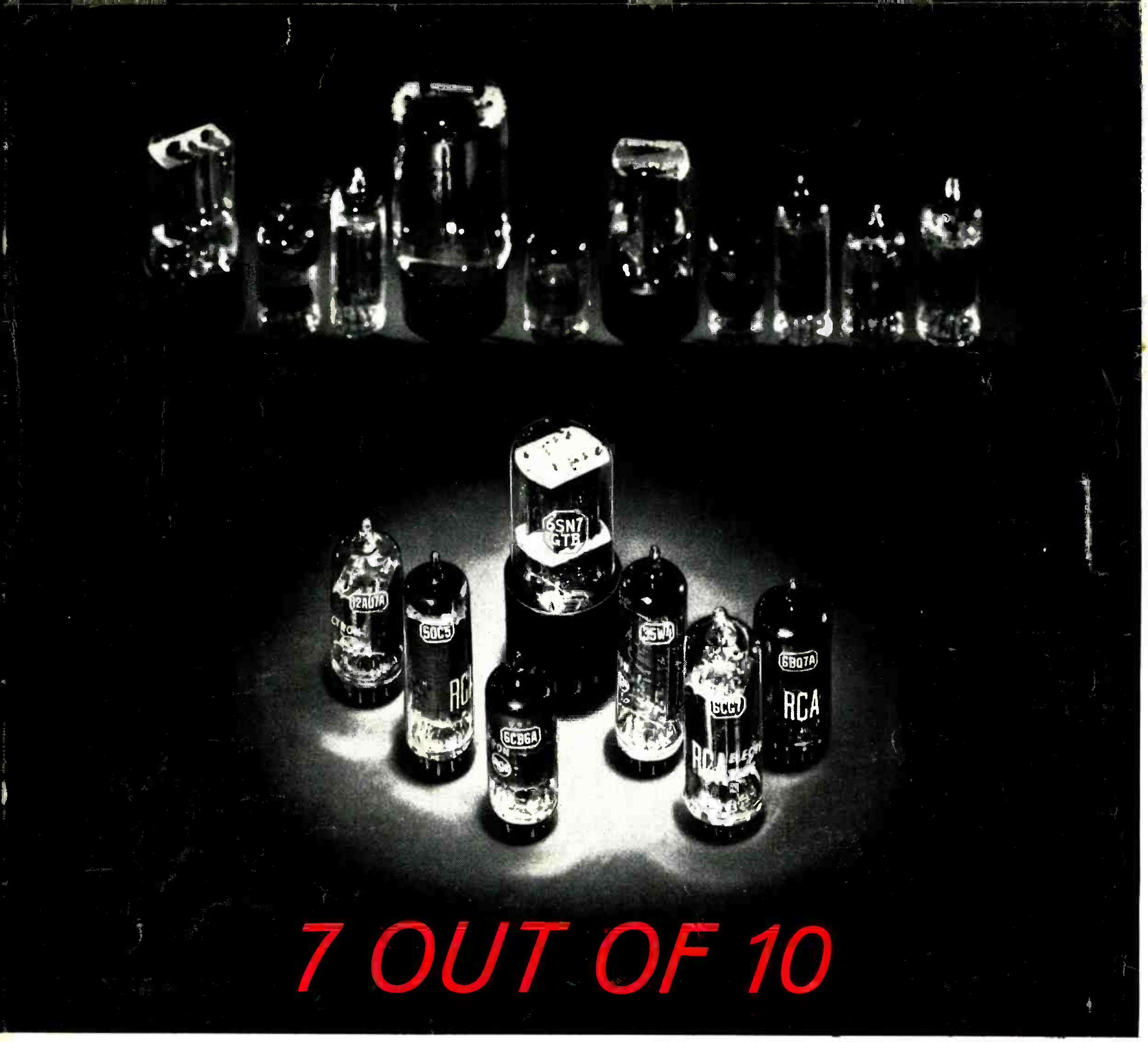

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